Notice No.3

Rules and Regulations for the Classification of Ships, July 2019

The status of this Rule set is amended as shown and is now to be read in conjunction with this and prior Notices. Any corrigenda included in the Notice are effective immediately.

Please note that corrigenda amends to paragraphs, Tables and Figures are not shown in their entirety.

Issue date: November 2019

Amendments to	Effective date	IACS/IMO implementation (if applicable)
Part 5, Chapter 2, Section 1	1 January 2020	N/A
Part 5, Chapter 2, Sections 2 & 7	1 January 2020	1 January 2020
Part 5, Chapter 6, Section 3	1 January 2020	1 January 2020
Part 5, Chapter 11, Section 1	1 January 2020	1 January 2020
Part 5, Chapter 12, Section 2	1 January 2020	1 January 2020
Part 5, Chapter 13, Sections 3 & 8	1 January 2020	1 January 2020
Part 5, Chapter 24, Sections 1 – 12	1 January 2020	N/A
Part 5, Chapter 25, Section 9	1 January 2020	N/A
Part 6, Chapter 1, Sections 1 & 2	1 January 2020	N/A
Part 6, Chapter 2, Sections 1, 9, 12, 17, 21 & 24	1 January 2020	N/A
Part 7, Chapter 11, Sections Scope, 1 – 3	1 January 2020	N/A
Part 7, Chapter 16, Sections 1 – 4	1 January 2020	1 January 2020

Lloyd's Register

Part 5, Chapter 2
Reciprocating Internal Combustion Engines

■ *Section 1*
General requirements

1.2 Scope

1.2.4 Primary exhaust gas emissions abatement plant, e.g. Exhaust Gas Recirculation (EGR), ~~(~~where fitted~~)~~, is to meet the requirements of this Chapter; additionally, it is to meet the applicable requirements of *Pt 5, Ch 24 Emissions Abatement Plant for Combustion Machinery*. Where secondary exhaust gas emissions abatement ~~systems~~ plants are fitted to engines, e.g. Scrubbers and Selective Catalytic Reduction (SCR), they are to meet the requirements of *Pt 5, Ch 24 Emissions Abatement Plant for Combustion Machinery*.

■ *Section 2*
Materials and Components

2.2 Testing and inspection

2.2.1 Materials and components for engines are to be manufactured, tested and documented in accordance with *Table 2.2.1 Summary of testing and associated documentation for engine components* under a quality control system that is suitable for the actual engine types to be certified by LR. *See also Pt 5, Ch 2, 2.2 Testing and inspection 2.2.4* and the applicable requirements specified in the *Rules for the Manufacture, Testing and Certification of Materials, July 2019*.

2.2.3 The testing and inspection in *Table 2.2.1 Summary of testing and associated documentation for engine components* is to be documented by the manufacturer (e.g. manufacturer certified materials testing or manufacturer issued NDT report as applicable), except where LR intervention is explicitly required, in which case an LR Component Certificate is to be issued which confirms conformity with the Rule requirements, with tests carried out on either the finished component itself, or on samples taken from earlier stages in the production of the component, as applicable.

2.2.4 ~~All material~~ Where an LR material certificate is specified for components listed in *Table 2.2.1 Summary of testing and associated documentation for engine components*, the material is to be from an LR approved manufacturer, and manufactured within the scope of approval of that manufacturer, except where explicitly stated otherwise in other Parts and Chapters of the Rules.

2.2.6 Where *Table 2.2.1 Summary of testing and associated documentation for engine components* states that a test report is required, this is to be issued by the manufacturer and provided for review by the Surveyor. The report is to identify the samples from the current production batch that have been tested and inspected to confirm that the component complies with all applicable requirements.

2.2.7 Where a manufacturer's document (test certificate or NDT report) is required in *Table 2.2.1 Summary of testing and associated documentation for engine components*, this is to be issued by the manufacturer and provided for review by the Surveyor. The document is to comply with the requirements of the *Rules for the Manufacture, Testing and Certification of Materials, July 2019, Ch 1, 3.1 General 3.1.3(c)* or *Ch 1, 5.5 Non-destructive examination reports 5.5.1* as applicable and is to identify the tests and inspections that have been carried out on the finished component itself or, where applicable, on samples taken from earlier stages in the production of the component.

(Part only shown)

Table 2.2.1 Summary of testing and associated documentation for engine components

Part	**Material properties *see* Note 2**	**Non-destructive examination**	**Hydraulic testing *see* Note 4**	**Dimensional inspection *see* Note 3**	**Visual inspection**	**Applicable to engines**	**Final document to be issued**
Cylinder block (grey cast iron or spheroidal graphite cast iron)	-	-	W (P) *see* Note 6	-	-	~~Crosshead~~ >400kW/cylinder	W Hydraulic Test Certificate
Piston rod	LR(C + M)	W (UT + CD)	-	-	LR(V) (Random)	Crosshead B>400mm	LR Component Certificate
High pressure fuel injection system – ~~valve and~~ pump body (pressure side) *see* Notes 10 1 and 11	~~-~~ W(C + M)	-	W (Lesser of P or *p*+30 MPa)	-	-	B>300mm	W Material Properties Certificate W Hydraulic Test Certificate or Test Report. *See* Note 14
			TR (Lesser of P or *p*+30 MPa)			B≤300mm	
High pressure fuel injection system – valves *see* Note 10	-	-	W (Lesser of P or *p*+30 MPa)	-	-	B>300mm	W Hydraulic Test Certificate or Test Report. *See* Note 14
			TR (Lesser of P or *p*+30 MPa)			B≤300mm	

High pressure fuel injection pipes including common rail *see* Note 10	W(C + M)	-	W (Lesser of P or *p*+30 MPa)	-	-	B>300mm	W Material Properties Certificate W Hydraulic Test Certificate or Test Report. *See* Note 14
			TR (Lesser of P or *p*+30 MPa)			B≤300mm	
High pressure common servo oil system	W(C + M)	-	W (Lesser of P or *p*+30 MPa)	-	-	B>300mm	W Material Properties Certificate W Hydraulic Test Certificate or Test Report. *See* Note 14
			TR (Lesser of P or P+30 MPa)			B≤300mm	
Coolers, both sides *see* Note 12	W(C + M)	-	W (P)	-	-	B>300mm	W Material Properties Certificate W Hydraulic Test Certificate. *See* Note 14
Accumulator ~~of common rail fuel or servo oil system~~	W(C + M)	-	W (Lesser of P or *p*+30 MPa)	-	-	Accumulators with a capacity >0,5l	W Material Properties Certificate W Hydraulic Test Certificate. *See* Note 14
Piping, pumps, actuators, etc., for hydraulic drive of valves, if applicable	W(C + M)	-	W (P)	-	-	>800kW/cylinder	W Material Properties Certificate W Hydraulic Test Certificate. See Note 14
Engine-driven pumps (oil, water, fuel, bilge) excluding those listed separately above	-	-	W (P)	-	-	>800kW/cylinder	W Hydraulic Test Certificate. *See* Note 14

SYMBOLS:

B = Bore dimension, refers to engine cylinder bores

C = Chemical composition analysis

M = Mechanical property analysis

UT = Ultrasonic testing (*see* Note 1)

CD = Crack detection by MPI or DPT (*see* Note 7)

W ( ) = Test/inspection to be certified by manufacturer

p = Maximum working pressure of item concerned

P = Pressure test at 1,5*p*

V = Visual examination of accessible surfaces

LR( ) = Test/inspection to be certified by LR

TR[ ] = Test report required for process in brackets (*see Pt 5, Ch 2, 2.2 Testing and inspection 2.2.6*)

Note 14. Material certification requirements for pumps and piping components are dependent on the operating pressure and temperature. Requirements given in this table apply except where alternative requirements are explicitly given elsewhere in the Rules. *See Pt 5, Ch 12, 1.7 Materials*.

■ *Section 7*
Control and monitoring of main, auxiliary and emergency engines

7.1 General

(Part only shown)

7.1.2 Oil mist detection or bearing temperature monitoring (or equivalent device in accordance with ~~SOLAS - International Convention for the Safety of Life at Sea Chapter II-1 - Construction - Structure, subdivision and stability, machinery and electrical installations, Part E - Additional requirements for periodically unattended machinery spaces Regulation 47 - Fire precautions .2~~ *SOLAS II-1, Regulation 47.2*) fitted as required by *Pt 5, Ch 2, 10.8 Oil mist detection 10.8.1* are to operate as follows:

(e) Where engine bearing temperature monitors or equivalent devices in accordance with ~~SOLAS - International Convention for the Safety of Life at SeaChapter II-1 - Construction - Structure, subdivision and stability, machinery and electrical installationsPart E - Additional requirements for periodically unattended machinery spacesRegulation 47 - Fire precautions .2~~ *SOLAS II-1, Regulation 47.2* are provided for the prevention of the build-up of oil mist that may lead to a potentially explosive condition within the crankcase, details are to be submitted for consideration. The submission is to demonstrate that the arrangements are equivalent to those provided by oil mist detection, *see Pt 5, Ch 2, 10.8 Oil mist detection 10.8.15*.

Where required, for each trunk piston engine, one oil mist detector (or engine bearing temperature monitoring system or equivalent device) having two independent outputs for initiating the alarm and shutdown would satisfy the requirement for independence between alarm and shutdown systems.

7.2 Main engine ~~governers~~ governors

7.2.3 When electronic speed governors of main internal combustion engines form part of a remote control system, they are to comply with the following conditions:

(a) If lack of power to the governor may cause changes in the present speed and direction of thrust of the propeller, which consequently compromises safe operation of the vessel, then backup power supply is to be provided;

(b) Local control of the engines is always to be possible. A means to effect safe transfer of control to the local control position and then control the engine is to be available in all normal and reasonably foreseeable abnormal conditions;

(c) In addition, electronic speed governors and their actuators are to be Type Approved in accordance with LR's *Type Approval System Test Specification Number 1*.

7.3 Auxiliary and emergency engine governors

Existing paragraphs 7.3.1 to 7.3.5 have been deleted and replaced with below.

7.3.1 Prime movers for driving generators of the main and emergency sources of electrical power are to be fitted with a speed governor which will prevent transient frequency variations in the electrical network in excess of ±10 per cent of the rated frequency, with a recovery time to steady state conditions not exceeding 5 seconds, when the maximum electrical step load is switched on or off.

7.3.2 In the case when a step load equivalent to the rated output of a generator is switched off, a transient speed variation in excess of 10 per cent of the rated speed may be acceptable, provided that this does not cause the intervention of the overspeed device as required by *Pt 5, Ch 2, 7.4 Overspeed protective devices*.

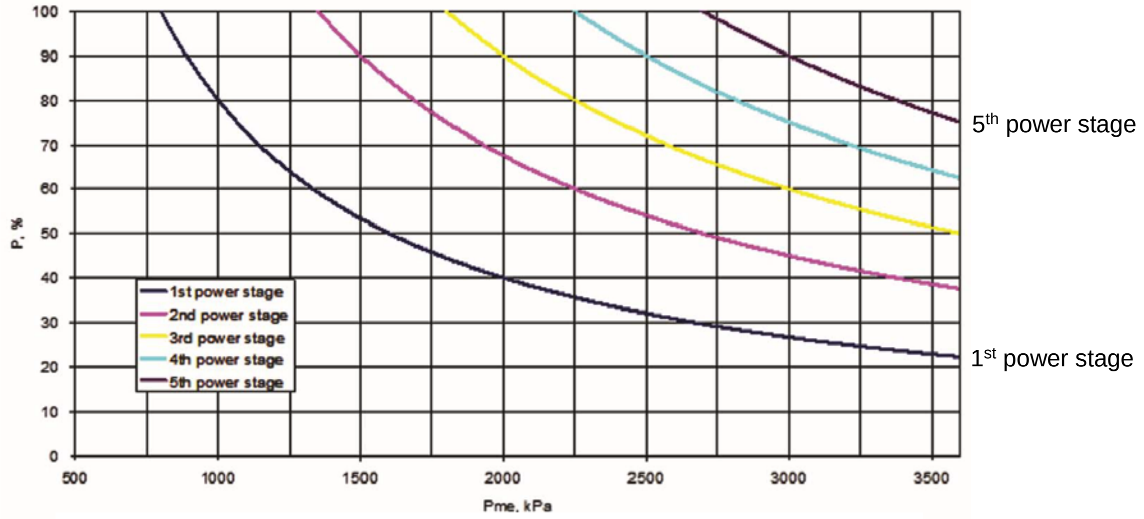
7.3.3 At all loads between no load and rated power, the permanent speed variation should not be more than ±5 per cent of the rated speed.

7.3.4 Prime movers are to be selected in such a way that they will meet the load demand within the ship's power distribution system. Application of electrical load should be possible with two load steps and must be such that prime movers, running at no load, can suddenly be loaded to 50 per cent of the rated power of the generator followed by the remaining 50 per cent after an interval sufficient to restore the speed to steady state. Steady state conditions should be achieved in not more than 5 seconds. Steady state conditions are those at which the envelope of speed variation does not exceed +1 per cent of the declared speed at the new power.

7.3.5 Application of electrical load in more than two load steps can only be permitted if the conditions within the ship's power distribution system permit the use of such prime movers which can only be loaded in more than two load steps (*see Figure 2.7.1 Reference values for maximum possible sudden power increase (four-stroke engines)*) and provided that this is already allowed for at the design stage. This is to be verified in the form of system specifications to be approved and to be demonstrated at ship's trials. In this case, due consideration is to be given to:

(a) The power required for the electrical equipment to be automatically switched on after black-out and to the sequence in which it is connected.

(b) Where generators are to be operated in parallel and where the power has to be transferred from one generator to another in the event of any one generator being switched off.



P_{me} : mean effective pressure at declared power
P : power increase referred to declared power at site conditions

Figure 2.7.1 Reference values for maximum possible sudden power increase (four-stroke engines)

7.3.6 Emergency generator sets are to comply with the requirements of *Pt 5, Ch 2, 7.3 Auxiliary engine governors 7.3.1* to *Pt 5, Ch 2, 7.3 Auxiliary engine governors 7.3.3* even when:

(a) their total consumer load is applied suddenly; or

(b) their total consumer load is applied in steps, subject to:

- the total load being supplied within 45 seconds of power failure on the main switchboard;

- the maximum step load being declared and demonstrated;
- the power distribution system being designed such that the declared maximum step loading is not exceeded; and
- the compliance of time delays and loading sequence with the above being demonstrated at ship's trials.

7.3.7 For a.c. generating sets operating in parallel, the governing characteristics of the prime movers shall be such that within the limits of 20 per cent and 100 per cent total load, the load on any generating set will not normally differ from its proportionate share of the total load by more than 15 per cent of the rated power of the largest machine, or 25 per cent of the rated power of the individual machine in question, whichever is the less. For an a.c. generating set intended to operate in parallel, facilities are to be provided to adjust the governor sufficiently finely to permit an adjustment of load not exceeding 5 per cent of the rated load at normal frequency.

7.3.8 For generator set voltage control requirements *see Pt 6, Ch 2, 9.4 Generator control.*

7.3.9 For quality of power supplies (QPS) requirements *see Pt 6, Ch 2, 1.8 Quality of power supplies*.

7.6 Engines for propulsion purposes

(Part only shown)

Table 2.7.1 Engines for propulsion purposes: Alarms and slow-downs

Item	**Alarm**	**Note**
~~Oil mist concentration in crankcase or bearing temperature~~ Activation of oil mist detection arrangements (or activation of the temperature monitoring systems or equivalent devices of: - the engine main, crank and crosshead bearing oil outlet; or - the engine main, crank and crosshead bearing)	High	~~*See Pt 5, Ch 2, 7.1 General 7.1.2.* Automatic slow-down of crosshead engines, for trunk piston engines *see Table 2.7.2 Engines for propulsion purposes: Automatic shutdowns.*~~ For crosshead engines, automatic slow-down. For trunk-piston engines, *see Table 2.7.2 Engines for propulsion purposes: Automatic shutdowns. See also Pt 5, Ch 2, 7.1 General 7.1.2.*

(Part only shown)

Table 2.7.2 Engines for propulsion purposes: Automatic shutdowns

Item	**Alarm**	**Note**
~~Oil mist concentration in crankcase or bearing temperature~~ Activation of oil mist detection arrangements (or activation of the temperature monitoring systems or equivalent devices of: - the engine main and crank bearing oil outlet; or - the engine main and crank bearing)	High	~~*See Pt 5, Ch 2, 7.1 General 7.1.2* Automatic shutdown of trunk piston engines, for crosshead engines *see Table 2.7.1 Engines for propulsion purposes: Alarms and slow-downs*~~ For trunk piston engines, automatic shutdown. For crosshead engines, *see Table 2.7.1 Engines for propulsion purposes: Alarms and slow-downs. See also Pt 5, Ch 2, 7.1 General 7.1.2.*

7.7 Auxiliary engines

(Part only shown)

Table 2.7.3 Auxiliary engines: Alarms and safeguards

Item	**Alarm**	**Note**
~~Oil mist concentration in crankcase or bearing temperature~~ Activation of oil mist detection arrangements (or activation of the temperature monitoring systems or equivalent devices of: - the engine main and crank bearing oil outlet; or - the engine main and crank bearing)	High	Automatic shutdown of engine, *see also Pt 5, Ch 2, 7.1 General 7.1.2*

7.8 Emergency engines

(Part only shown)

Table 2.7.4 Emergency engines: Alarms and safeguards

Item	**Alarm for engine power < 220 kW**	**Alarm for engine power ≥ 220 kW**	**Note**
~~Oil mist concentration in crankcase~~ Activation of oil mist detection arrangements (or activation of the temperature monitoring systems or equivalent devices of: - the engine main and crank bearing oil outlet; or - the engine main and crank bearing)	—	High	*See* Note
Note For engines having a power of more than 2250 kW or a cylinder bore of more than 300 mm.			

Part 5, Chapter 6
Main Propulsion Shafting

■ *Section 3*
Design

3.12 Sternbushes

3.12.4 Synthetic materials for application as water lubricated stern tube bearings are to be approved in accordance with *Rules for the Manufacture, Testing and Certification of Materials, July 2019, Ch 14, 2.13 Sterntube bearings 2.13.1.*

Existing paragraphs 3.12.4 to 3.12.12 have been renumbered 3.12.5 to 3.12.13.

Part 5, Chapter 11
Other Pressure Vessels

■ *Section 1*
General requirements

1.1 Application

1.1.1 The requirements of this Chapter are applicable to fusion welded pressure vessels, including process pressure vessels, and ~~plate~~ heat exchangers, intended for marine purposes but not included in *Pt 5, Ch 10 Steam Raising Plant and Associated Pressure Vessels*. The equations in this Chapter may be used for determining the thickness of seamless pressure vessels using a joint factor of 1,0. Seamless pressure vessels are to be manufactured and tested in accordance with the requirements of *Ch 5 Steel Forgings* of the *Rules for the Manufacture, Testing and Certification of Materials, July 2019* ~~(hereinafter referred to as the Rules for Materials)~~. For the construction and design of pressure vessels and plate heat exchangers for liquefied gas or chemical cargo applications, *see* the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk, July 2019* ~~(hereinafter referred to as the Rules for Ships of Liquid Gases)~~ or the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquid Chemicals in Bulk, July 2019* ~~(hereinafter referred to as the Rules for Ships of Liquid Chemicals)~~ or the *Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels, July 2019* as applicable.

1.1.4 For the use of alternative design standards for pressure vessels and heat exchanges *see Pt 5, Ch 11, 11.2 Alternative standards for design*.

1.12 Alternative standards for design

1.12.1 Pressure vessels and heat exchangers designed in accordance with an appropriate and established National or International Code or Standard considered acceptable by LR may be accepted subject to agreement.

1.12.2 The Code or standard is to fully address the proposed design and provide for an overall level of safety equivalent to that provided by the Rules which is to be established and agreed with LR.

1.12.3 For designs already addressed within the Rules, corrosion allowances, wall thicknesses for pressure boundaries and hydrostatic test pressures are to be in accordance with the relevant requirements of the Rules irrespective of the requirements of the Code or standard.

1.12.4 The allowable design stress is to be in accordance with the Code or Standard but is not to exceed allowable design stress within the Rules.

1.12.5 The requirements in the Rules for materials are to be satisfied.

1.12.6 The mixing of different parts of Codes and Standards is not permitted.

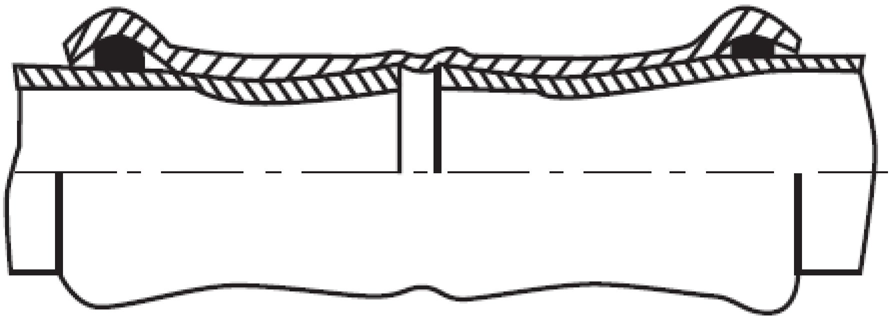
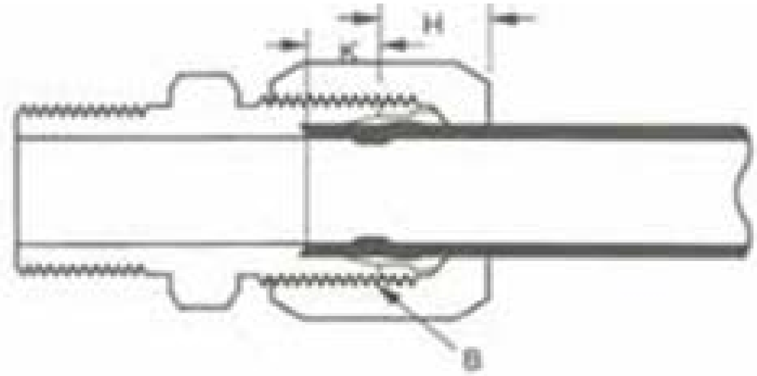
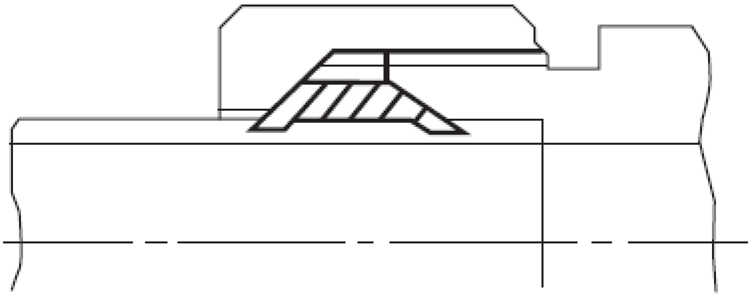
Part 5, Chapter 12
Piping Design Requirements

■ *Section 2*
Carbon and low alloy steels

2.12 Other mechanical couplings

(Part only shown)

Figure 12.2.4 Examples of mechanical joints (Part 1)

Compression Couplings	
Press Type	
Typical Compression Type	
Bite Type	

(Part only shown)

Table 12.2.7 Application of mechanical joints

Note 2. Slip on joints are not accepted inside machinery spaces of category A or accommodation spaces. They may be acceptable in other machinery spaces provided the joints are located in easily visible and accessible positions. ~~Mechanical joints that include any components which readily deteriorate in case of fire are not permitted machinery spaces of category A or accommodation spaces. Mechanical joints that include any components which readily deteriorate in case of fire that are of an approved fire-resistant type may be fitted in other machinery spaces provided the joints are located in easily visible and accessible positions.~~

Note 3. ~~Mechanical joints that include any components which readily deteriorate in case of fire fitted on fuel oil lines are to be of an approved fire-resistant type. Mechanical joints that include any components which readily deteriorate in case of fire fitted on other systems are to be of an~~ Mechanical joints are to be of an approved fire-resistant type except when they are fitted on open decks having little or no fire risk as defined in SOLAS II-2/Reg. 9.2.3.3.2.2(10).

(Part only shown)

Table 12.2.8 Application of mechanical joints depending upon the class of piping

Type of joints	**Classes of piping systems**		
	Class I	Class II	Class III
Compression Couplings			
Swage type	+	+	+
Bite type	+ (OD ≤ 60,3mm)	+ (OD ≤ 60,3mm)	+
Typical compression type	+ (OD ≤ 60,3mm)	+ (OD ≤ 60,3mm)	+
Flared type	+ (OD ≤ 60,3mm)	+ (OD ≤ 60,3mm)	+
Press type	-	-	+

Part 5, Chapter 13

Ship Piping Systems

■ *Section 3*

Drainage of compartments, other than machinery spaces

3.5 Fore and after peaks

3.5.4 Except as permitted by *Pt 5, Ch 13, 3.5 Fore and after peaks 3.5.5*, the collision bulkhead ~~is not to be pierced below the bulkhead deck by~~ may be pierced below the bulkhead deck of passenger ships and the freeboard deck of cargo ships by not more than one pipe for dealing with the contents of the fore peak. The pipe is to be provided with a screw-down valve capable of being operated from an accessible position above the bulkhead deck of passenger ships and the freeboard deck of cargo ships, the chest being secured to the bulkhead inside the fore peak. An indicator is to be provided to show whether the valve is open or closed. The valves may be fitted on the after side of the collision bulkhead, provided that the valve is readily accessible under all service conditions and the space in which it is located is not a cargo space. Alternatively, for cargo ships, the pipe may be fitted with a butterfly valve suitably supported by a seat or flanges and capable of being operated from above the freeboard deck.

3.5.5 Where the fore peak is divided into two compartments, the collision bulkhead may be pierced below the bulkhead deck of passenger ships and the freeboard deck of cargo ships by two pipes (i.e. one for each compartment) provided there is no practical alternative to the fitting of a second pipe. Each pipe is to be ~~provided with a screw-down valve,~~ fitted and controlled as in *Pt 5, Ch 13, 3.5 Fore and after peaks 3.5.4*.

■ *Section 8*

Additional requirements for bilge drainage and cross-flooding arrangements for passenger ships

8.1 Location of bilge pumps and bilge main

8.1.2 In passenger ships of 91,5 m or more in length or having a bilge pump numeral of 30 or more (*see Pt 5, Ch 13, 6.1 Number of pumps 6.1.5*), the arrangements are to be such that at least one power pump will be available for use in all ordinary circumstances in which the ship may be flooded at sea. *See also* SOLAS 1974, as amended, Chapter II-1, Regulation 35-1 Bilge pumping arrangements. This requirement will be satisfied if:

- one of the pumps is an emergency pump of a submersible type having a source of power situated above the bulkhead deck, or
- the pumps and their sources of power are so disposed throughout the length of the ship that, under any conditions of flooding which the ship is required by statutory regulation to withstand, at least one pump in an undamaged compartment will be available.

Part 5, Chapter 24
Emissions Abatement Plant for Combustion Machinery

■ *Section 1*
General

1.1 Scope

(Part only shown)
1.1.1 The requirements are applicable to emissions abatement plant making use of both primary techniques, which reduce emissions by controlling the combustion process or removing pollutants prior to combustion, e.g. Exhaust Gas Recirculation (EGR), and to secondary emissions abatement techniques which reduce emissions from the exhaust gas after combustion, e.g. Scrubbers and Selective Catalytic Reduction (SCR). Emissions abatement plant making use of primary techniques is also to satisfy the applicable requirements of *Pt 5, Ch 2, Reciprocating Internal Combustion Engines (See Pt 5, Ch 2, 1.2 Class notation and descriptive note 1.2.4)*.

1.2 Class notation and descriptive note

1.2.1 Ships complying with the relevant SO_x emissions abatement plant requirements of this Chapter will be eligible for assignment of the **EGCS()** machinery notation. This notation is to be assigned with one of the following associated notations depending on the type of SO_x emissions abatement plant that is installed on board, e.g. Scrubber:

(Open) Open loop wet scrubber installed with no capacity to operate in zero discharge mode;
(Closed) Closed loop wet scrubber installed only capable of operating in zero discharge mode;
(Hybrid) The installed wet scrubber is able to operate in both open loop and closed loop modes; or
(Dry) Dry scrubber installed.

The **EGCS()** notation indicates that the SO_x emissions abatement plant has been designed, constructed, arranged, installed and tested in accordance with LR's Rules and Regulations. Application of the **EGCS()** notation does not infer that the installation meets applicable statutory emissions regulations. Where the installed SO_x emissions abatement plant is not intended to reduce the emissions produced by all fuel oil combustion machinery, excluding shipboard incinerators fitted on board that are required to comply with other statutory emissions regulations and machinery used for emergency purposes such as emergency generators, the notation 'Partial' is to be appended to the **EGCS** notation, e.g. **EGCS(Open, Partial)**.

1.2.2 Ships complying with ~~particular~~ relevant SO_x emissions abatement plant requirements of this chapter may be eligible for the Exhaust Gas Cleaning System Ready **(EGCS-R())** descriptive note. This descriptive note may be assigned when aspects of design and construction are prepared for installation of SO_x emissions abatement plant for combustion machinery, e.g. Scrubber. This is not an LR class notation and is provided solely for information.

EGCS-R() Assigned to ships with the extension of one or more of the following associated characters shown in brackets, detailing the aspects of design and construction that are in accordance with LR's Rules and Regulations in force on the date of 'contract for construction':

A Preliminary assessment of the proposed SO_x emissions abatement ~~system~~ plant including its arrangement on board has been completed satisfactorily;

S Enhanced structural reinforcement and structural modifications necessary for the function of the proposed SO_x emissions abatement plant have been fitted under survey. For open loop systems this includes any necessary enlargement of sea chests and fitting of additional sea water inlets for future use;

T The relevant tank(s) needed for operation of the proposed SO_x emissions abatement ~~system~~ plant (e.g. chemical and/or residue storage tanks as applicable) have been installed under survey in accordance with approved design.

Where the proposed SO_x emissions abatement plant is not intended to reduce the emissions produced by all fuel oil combustion machinery, excluding shipboard incinerators fitted on board that are required to comply with other statutory emissions regulations and machinery used for emergency purposes such as emergency generators, the notation **'Partial'** is to be appended to the **EGCS** descriptive note with applicable characters, e.g. **EGCS-R(A, Partial)**, **EGCS-R(A, Closed, Partial, T)**, as appropriate. Further appraisal against the LR requirements at the time of installation followed by testing under survey will be required when the emissions abatement plant is to be installed. Application of the **EGCS-R()** descriptive note does not infer that the proposed installation will meet the statutory requirements for emissions regulation.

(Part only shown)
1.2.3 The following are to be submitted to achieve **EGCS-R** descriptive note with applicable associated characters:

(b) **EGCS-R(S)** 'Structural reinforcement fitted'
  o Full details of the structural reinforcement required to support the proposed SO_x emissions abatement plant are to be submitted. This should include details of the proposed plant type, size, location and loadings (dynamic and static) to allow verification of the submitted structural design and calculations for the plant support arrangements.

(c) **EGCS-R(T)** 'Tank installed'
  o Details of the flammability, toxicity, corrosivity and reactivity of any chemicals to be stored in the tanks. This is to include effluent and sludge associated with the SO_x emissions abatement plant, and the corrosivity of wash water for wet scrubbing systems;

1.2.4 Ships complying with the relevant NO_x emissions abatement plant requirements of this Chapter will be eligible for assignment of the **EGCN()** machinery notation. This notation is to be supplemented by the following associated notation(s) depending on the type of NO_x emissions abatement plant that is installed on board, e.g. SCR:

(SCR) Selective Catalytic Reduction installed.

1.2.5 Ships complying with particular NO_x emissions abatement plant requirements of this Chapter may be eligible for the Exhaust Gas Cleaning for NO_x Ready **(EGCN-R())** descriptive note. This descriptive note may be assigned when aspects of design and construction are prepared for installation of NO_x emissions abatement plant for combustion machinery, e.g. SCR. This is not an LR class notation and is provided solely for information.

EGCN-R() Assigned to ships with the extension of one or more of the following associated characters shown in brackets, detailing the aspects of design and construction that are in accordance with LR's Rules and Regulations in force on the date of 'contract for construction':

A Preliminary assessment of the proposed NO_x emissions abatement plant including its arrangement on board has been completed satisfactorily;

S Enhanced structural reinforcement and structural modifications necessary for the function of the proposed NO_x emissions abatement plant have been fitted under survey;

T The relevant tank(s) needed for operation of the proposed NO_x emissions abatement plant (e.g. chemical tanks) have been installed under survey in accordance with approved design.

1.2.6 The following are to be submitted to achieve **EGCN-R()** descriptive note with applicable associated characters:

(a) **EGCN-R(A)** 'Preliminary assessment'
- Vessel general arrangement;
- General arrangement of NO_x emissions abatement plant illustrating the locations of NO_x emissions abatement machinery and tanks with respect to machinery, control and service spaces;
- Exhaust system arrangement (showing necessary modifications for installation of the proposed NO_x emissions abatement plant);
- Arrangement and capacity of tanks for storage of chemicals;
- Information on the operational requirements of the proposed NO_x emissions abatement plant with respect to additional chemical requirements as applicable;
- Electrical system requirements including details of how the proposed system is to be incorporated into the vessel's electrical system; and
- Preliminary studies for vessel loadline and stability taking the proposed NO_x emissions abatement plant installation into account.

(b) **EGCN-R(S)** 'Structural reinforcement fitted'
- Full details of the structural reinforcement required to support the proposed NO_x emissions abatement plant are to be submitted. This should include details of the proposed plant type, size, location and loadings (dynamic and static) to allow verification of the submitted structural design and calculations for the plant support arrangements.

(c) **EGCN-R(T)** 'Tank installed'
- Plans and information required for **EGCN-R(S)** descriptive note;
- Structural plans for tanks to be installed, and any additional support arrangements where necessary for independent tanks, in accordance with *Pt 3, Ch 1, 2 Direct calculations*;
- Full details of the materials proposed for construction of the tank(s);
- Details of the flammability, toxicity, corrosivity and reactivity of any chemicals to be stored in the tanks. This is to include effluent associated with the NO_x emissions abatement plant;
- Details of air and sounding pipes to tanks containing chemicals, substances and effluent; and
- Details of arrangements for loading, storage, transfer and disposal of chemicals, by-products or waste products. This is to include allowable maximum and minimum storage temperatures for substances which are sensitive to temperature.

1.2.7 Where a primary NO_x emissions abatement plant is fitted to the ship's engine(s), e.g. EGR, the ship will be eligible for the assignment of the **EGCN()** machinery notation with the following notation, subject to complying with the applicable requirements given in *Pt 5, Ch 2 Reciprocating Internal Combustion Engines* and this Chapter:

(EGR) Exhaust Gas Recirculation installed.

■ *Section 2*
Functional requirements

2.1 Functional requirements of emissions abatement plant

2.1.1 Emissions abatement plant is to be capable of operating at the stated maximum ~~output power~~ operating limits of the combustion machinery to which it is connected. Where the machinery installation is configured such that it is not intended to operate all the combustion machinery connected to the emissions abatement plant simultaneously in normal operating conditions, this will be subject to special consideration and supported by the submission required by *Pt 5, Ch 24, 3.1 General 3.1.2*. ~~For engines, the maximum power is as stated on the Engine International Air Pollution Prevention Certificate (EIAPPC) or an equivalent certificated engine rating for vessels which are not subject to MARPOL *Annex VI - Regulations for the Prevention of Air Pollution from Ships*.~~

■ *Section 3*
Information to be submitted

3.1 General

3.1.2 A description of the emissions abatement plant and the abatement technique(s) used. This is to include details of the proposed combustion machinery operating configurations where using a common emissions abatement ~~system~~ plant for multiple exhaust gas inlet streams and any limitations on the operation of combustion machinery connected to the emissions abatement ~~system~~ plant.

3.1.5 ~~Details of the maximum and minimum ambient and sea-water temperatures within which the emissions abatement plant is to operate, and maximum and minimum ambient air temperature and humidity where applicable.~~ A list of system main components and associated ancillaries.

3.1.6 Details of the hazards associated with operation and maintenance and reasonably foreseeable failure of the emissions abatement plant and the means by which they are mitigated in accordance with the requirements given in *Pt 5, Ch 24, 6 Mechanical equipment*. The details of impact on the operation of essential services due to failure of the emissions abatement plant and proposed mitigation measures are to be submitted.

3.1.8 Material Safety Data Sheets (MSDS) and details for handling of hazardous and non-hazardous chemicals used in the emissions abatement plant in accordance with *Pt 5, Ch 24, 6.1 General 6.1.7*.

3.1.9 Testing procedures for installation and commissioning trials.

3.1.10 Where failure of components and equipment in the emissions abatement plant will affect essential services, appropriate certification for such components and equipment shall be submitted as agreed with LR.

3.1.11 Exhaust back-pressure calculations in accordance with *Pt 5, Ch 24, 6.4. Maintenance of back-pressure*.

3.2 Materials and hull construction

3.2.2 Plans showing the foundation and attachments of emissions abatement plant to the ship structure, including scantlings, and welding details.

3.2.3 Full details of the structural reinforcement required to support the proposed emissions abatement plant are to be submitted, including plant type, size, location and loadings (dynamic and static) to allow verification of the submitted structural design and calculations for the plant support arrangements.

3.3 Chemical substances

3.3.1 Details of the flammability, toxicity, corrosivity and reactivity of any chemicals used, together with details of any exothermic and hazardous reactions, particularly with regard to sea-water. This is to include effluent and sludge associated with emissions abatement plant~~, and the corrosivity of wash water for wet scrubbing systems~~.

3.6 Pumping and piping

3.6.6 The arrangements for the storage on board the ship, and the disposal, of bilge and effluent from the emissions abatement plant spaces, giving particular consideration to the risk of flooding as a result of emissions abatement plant failure. Recognition is to be given to the requirements of the appropriate National Authority. An inspection and maintenance schedule is to be submitted, describing the items such as, but not limited to, inspection procedures for coating, pipe corrosion and their inspection intervals.

■ *Section 4*
Materials

4.1 General

4.1.1 The materials used in the construction of the emissions abatement plant and any associated chemical and effluent storage tanks are to be manufactured and tested in accordance with the requirements of the *Rules for the Manufacture, Testing and Certification of Materials*, *July 2019* or a relevant National or International Standard acceptable to LR.

■ *Section 5*
Hull construction

5.1 General

(Part only shown)

5.1.4 Where necessary, the probable temperature variations during operations and the thermal stress considerations are to be stated. Where it is necessary either to heat or cool chemical storage tanks, the arrangements are to utilise either pipe coils or ducts for circulating a heating or cooling medium within the chemical storage tank or a heat exchanger through which the chemical and a heating or cooling medium is circulated. Active heating and cooling systems are to have the capacity to maintain the chemical in the designated tank within the specified temperature limits, *see Pt 5, Ch 24, 3.3 Chemical substances 3.3.3*, *Pt 5, Ch 24, 3.4 Mechanical equipment 3.4.4* and *Pt 5, Ch 24, 7.1 General ~~7.1.10~~ 7.1.9* under the following conditions:

5.1.7 ~~Tanks are to be arranged such that any residues and slops can be pumped out, drained or otherwise removed from the tank without exposing personnel to these residues and slops.~~ Chemical storage tanks and any other tanks which may contain liquids hazardous to personnel are to be arranged such that residues and slops can be pumped out, drained or otherwise removed from the tank without exposing personnel.

5.1.8 Chemical storage tanks containing substances which are categorised as a safety hazard in Chapter 17 of the Rules for Ships for Liquid Chemicals (designated by letter “S” in column d) are ~~not to be~~ subject to special consideration where they are located in the same space as essential services, e.g. main combustion machinery and equipment. These tanks are to form part of the ship’s structure and the area of the tank boundary common with the machinery spaces is to be kept to a minimum as required for fuel oil tanks, as far as practicable. Tanks for chemical substances are not to be situated where spillage or leakage therefrom can constitute a hazard by dripping or spraying onto combustibles or hot surfaces.

5.1.9 Arrangements for venting and gas freeing chemical tanks required by emissions abatement plant are to meet the requirements of *Pt 5, Ch 13, 12 Air, overflow and sounding pipes* and they are to be independent of the air pipes and venting systems of other tanks and/or compartments of the ship. Sounding pipes are to be led to the safe position on the open deck. Alternatively, sounding devices of approved type may be used in lieu of sounding pipes. Tank venting systems are to minimise the possibility of chemical vapour accumulating on the decks, entering accommodation, service and machinery spaces, and control stations and, in the case of flammable vapours, entering or collecting in spaces or areas containing sources of ignition. Tank venting systems are to be arranged to prevent entrance of water into the chemical tanks. The venting systems shall be connected to the top of each chemical tank. As far as practicable, they are to be self-draining back to the chemical tanks under all normal operational conditions of list and trim.

5.2 Location service and control spaces

5.2.2 Arrangements are to be made in spaces occupied by emissions abatement plant, in order that substances which are flammable, corrosive, toxic or likely to present a hazard due to reaction when mixed are kept separate unless they are fully contained within a part of the emissions abatement ~~system~~ plant which has been designed for the safe mixing of such substances.

5.4 Plant support structure

~~5.4.2 Where the nature and dispositions of heavy plant items are such that forces on the ship and support structure due to ship motions are significant (whether underway with or without working fluids, or moored with working fluids), calculations of the loading and the structural response are to be submitted.~~

~~5.5 Loading due to wave-induced motions~~

~~5.5.1 In cases where the mass distribution of large columnar equipment items is such that the centre of action of the dynamic force differs significantly from the centre of gravity of the item, due account of this is to be taken in the calculation of the forces and moments at the support positions.~~

~~5.6 Integrity of weather deck~~

~~5.6.1 The integrity of the weather deck is to be maintained. Where items of plant penetrate the weather deck and are intended to constitute the structural barrier to prevent the ingress of water to spaces below the freeboard deck, their structural strength is to be equivalent to the Rule requirements for this purpose. Otherwise, such items are to be enclosed in superstructures or deckhouses fully complying with the Rules.~~

■ *Section 6*
Mechanical equipment

6.2 By-pass or equivalent arrangements

6.2.2 Where a by-pass is fitted, there is to be a flow path for exhaust gas at all times. The essential services shall not be impacted during the by-pass operation.

6.2.4 The by-pass valves are to be remotely operated from the control station. In the event of failure or loss of power to the actuator(s), by-pass valves shall fail to the open position.

6.2.5 An interlock arrangement is to be provided to ensure by-pass valves are open prior to blocking exhaust gas flow into the emissions abatement plant.

6.2.6 The activation of by-pass mode is to be automatic for conditions which activate a shutdown of the emissions abatement plant, *see Table 24.9.1 Machinery emissions to air abatement plant: alarms and safeguards*, to ensure that essential services are not impacted.

6.4 Maintenance of back-pressure

6.4.4 Emissions abatement plant in which both a scrubber and SCR are fitted together in series in an exhaust piping system will be subject to special consideration.

6.5 Protection of combustion machinery

6.5.5 Where exhaust gas is ~~re-circulated~~ recirculated as a means of emissions abatement, e.g. EGR, the ~~re-circulated~~ recirculated exhaust gas is not to cause fouling and corrosion of critical engine components and scavenge air temperature is to be maintained at a level which does not adversely affect engine performance.

6.5.6 Where a wet scrubber is used to clean and cool recirculated exhaust gas, the scrubber is to satisfy the requirements of *Pt 5, Ch 24, ~~7~~11.1 General ~~7.1.9~~ 11.1.8*.

■ *Section 7*
Pumping and piping

7.1 General

7.1.1 Pipe work and transfer systems which may carry chemical substances are to meet the requirements of *Pt 5, Ch 12 Piping Design Requirements*, *Pt 5, Ch 13 Ship Piping Systems* and *Pt 5*, *Ch 14 Machinery Piping Systems*, as applicable. Pipe joints for chemical substances which are categorised as a safety hazard in *Chapter 17* of the Rules for Ships for Liquid Chemicals (designated by letter “S” in column d) are to be butt-welded, except in way of valves or equipment, and Class I piping systems are to be used regardless of design pressure in storage, handling and supply systems. Where it is proposed to apply corrosion resistant lining to steel pipe systems then such lining is to be confirmed as being suitable for the application, in accordance with *Pt 5, Ch 24, 4.1 General 4.1.2*. The elasticity of the lining is not to be less than that of the supporting boundary material.

7.1.3 Chemical transfer and control arrangements are to be provided with a stop-valve, capable of being manually operated on each tank filling and discharge line, which where practicable is to be attached directly to the tank plating. Additionally, a stop valve is to be provided at each chemical-hose loading connection. Where there is a possibility of gravity discharge of the tank contents in the event of a pipe or valve failure then the ~~discharge~~ stop valve is to be of the quick ~~closing~~ shut-off type and where the chemical is categorised as a safety hazard in *Chapter 17* of the Rules for Ships for Liquid Chemicals (designated by letter “S” in column d), the stop valve is to be remotely operated and be capable of local manual closure. The closure of the valve shall not impact the operation of essential services.

7.1.6 Bilge and effluent pumping and piping systems for hazardous materials should, wherever possible, be installed in the space associated with the particular hazard. Alternative arrangements will be subject to special consideration.

7.1.8 Where filters are used, they are to be capable of being ~~safely removed for cleaning and replacement~~ safely cleaned and maintained without ~~interrupting emissions abatement plant or engine operations~~ impacting essential services.

~~7.1.9 Where scrubbers are used, the following apply:~~

~~(a) Closed loop wet scrubbers are to have natural gravity fall drainage from the wet sump of the scrubber to the process tank or circulating pump suction, with the drain line dimensioned to accommodate 125 per cent of the maximum pumping capacity of the installed water pump(s). No valves are to be fitted to the drain line from the scrubber sump to the process tank unless it can be demonstrated that suitable precautions are in place to prevent the possibility of the scrubber filling with water and reverse-flowing into the engine exhaust duct. Where a valve is fitted to this line, the system is to be protected as for the overboard discharge valve of an open loop system, in accordance with *Pt 5, Ch 24, 9.1 General 9.1.8*.~~

~~(b) For open loop wet scrubbers, the overboard discharge valve and any other sea-water valves downstream of the scrubber are to be protected in accordance with *Pt 5, Ch 24, 9.1 General 9.1.8*. The sea suction valve(s) are also to have position indicators which are to give remote indication of valve position. The scrubber is to be mounted above the waterline under all operating conditions to prevent seawater ingress into the scrubber from the natural flow.~~

~~(c) For wet scrubbing systems (open loop and closed loop), an overflow line is to be fitted to prevent the risk of reverse flow of water to engines, boilers and other machinery. This overflow is to be dimensioned to accommodate 125 per cent of maximum capacity of installed water pumps and is to have no impairment to flow. This overflow line is to be directed to the process tank in closed loop or hybrid installations. On open loop installations, it is to be directed overboard. The overboard discharge is to have an effective means of preventing reverse flow of sea-water. Alternative arrangements to prevent the risk of reverse flow are subject to special consideration.~~

~~(d) Overboard discharge connections from scrubbers are to be positioned below the lowest operating waterline and are to be internally protected from effluent-induced corrosion.~~

~~7.1.10~~ 7.1.9 Where applicable, tanks are to be maintained within the temperature limits of the chemicals and substances they contain so as to avoid risks of boiling, stress corrosion, freezing and other temperature-sensitive processes.

7.1.10 The loading or discharge connections associated with chemical substances are to be located on the open deck away from sources of ignition and arranged such that a spill or any leakage at loading or discharge connections would not result in chemical substances contacting or mixing with other incompatible materials; alternative arrangements will be subject to special consideration. Drip trays having means of drainage to the dedicated residue or overflow tank are to be provided.

7.1.11 The overboard discharge is to be independent of other systems and arranged in such a way as to prevent the discharge water from being drawn into sea suctions for other pipe systems.

7.1.12 Where the emissions abatement plant is fed from multiple exhaust streams, gas inlet piping is to have separate inlets unless arranged with suitable by-pass arrangements to prevent any impact on essential services in the event of failure. The inlets are also to have suitable arrangements to prevent exhaust backflow down any of the exhaust gas inlets.

■ *Section 8*
Pressure vessels

8.1 General

8.1.1 Pressure vessels are to be in accordance with the requirements of the relevant Sections of *Pt 5, Ch 10 Steam Raising Plant and Associated Pressure Vessels* or *Pt 5, Ch 11 Other Pressure Vessels* as applicable, or with agreed Codes and specifications normally used for similar plants in land installations, suitably modified and/or adapted for the marine environment.

~~8.1.2 Mounting arrangements are to take account of forces and moments generated at the supports. Mounting arrangements are to take account of thermal expansion and contraction.~~

~~8.1.3 Access is to be provided for inspection, and checking of mountings, fittings, controls and pressure-relief devices.~~

~~8.1.4 Arrangements are to allow the pressure settings of pressure-relief devices to be checked.~~

~~8.1.5 Where provision is made to isolate pressure-relief devices from pressure vessels for maintenance purposes, at least two such pressure-relief devices are to be fitted.~~

~~The isolating or blocking valves are to be arranged such that at least one pressure-relief device remains operational at all times.~~

■ *Section 9*
Electrical and control equipment

9.1 General

9.1.4 Where flammable or toxic chemicals, gases or vapours are present, as identified in *Pt 5, Ch 24, 3.3 Chemical substances 3.3.1* and *Pt 5, Ch 24, 3.3 Chemical substances 3.3.2*, or where there is a possibility that flammable gases and vapours can be produced as a result of deviations from normal operation, the defining of hazardous zones is to be in accordance with *Pt 6, Ch 2, 14 Electrical equipment for use in explosive gas atmospheres or in the presence of combustible dusts*.

~~As a minimum, for the detection of gas and vapours, a gas detection system is to be fitted which is to activate at a concentration corresponding to the substance safe occupational level. The locations of the detectors are to be determined relative to the layouts of the individual spaces and are to be indicated on the plan submission required by *Pt 5, Ch 24, 3.3 Chemical substances 3.3.9*. Where it is not practicable to install a detection system where gas detection equipment is not appropriate, e.g. for substances not emitting gases or vapours, alternative proposals are to be submitted to ensure the safety of persons from exposure to such substances.~~

9.1.5 For the detection of gas and vapours, a gas detection system is to be fitted which is to activate at a concentration corresponding to the substance safe occupational level. The locations of the detectors are to be determined relative to the layouts of the individual spaces and are to be indicated on the plan submission required by *Pt 5, Ch 24, 3.3 Chemical substances 3.3.9*. Where gas detection equipment is not appropriate, e.g. for substances not emitting gases or vapours, alternative proposals are to be submitted to ensure the safety of persons from exposure to such substances.

~~9.1.5~~ 9.1.6 Process tanks which form part of the operating loop of any emissions abatement equipment are to have a high level alarm, in accordance with *Table 24.9.1 Machinery emissions to air abatement plant: alarms and safeguards*. Effluent tanks which are not part of the normal process loop and which are used for storage of effluent or substances prior to discharge from the vessel are to be protected, in accordance with *Table 24.9.1 Machinery emissions to air abatement plant: alarms and safeguards*.

~~Tank alarm and trip sensors are to be positioned at a point which will allow the system shutdown to operate before the tank overflows, based on the maximum design flow rates and shut-down response time. Where a low level is identified as presenting a risk to crew or machinery, tanks are to have a low level alarm and a low level trip. These are to be positioned so as to operate before a low level results in a hazardous condition, based on system design flow rates and a system shut-down response time.~~

9.1.7 Tank alarm and shutdown sensors are to be positioned at a point which ensure a system shutdown before the tank overflows, based on the maximum design flow rates and shutdown response time. Where a low level is identified as presenting a risk to crew or machinery, tanks are to have a low level alarm and a low level shutdown. These are to be positioned so as to operate before a low level results in a hazardous condition, based on system design flow rates and a system shutdown response time.

(Part only shown)

~~9.1.6~~ 9.1.8 An emergency stop function is to be provided, which is to:

- Close ~~quick-closing~~ remote shut-off valves on chemical tank(s) (where applicable, *).

Note * Not required for emissions abatement plant utilising urea solution, *see also Pt 5, Ch 24, ~~10 Storage and use of chemicals~~ 7.1 General 7.1.3*. Systems using other media are to be considered on a case-by-case basis.

Existing paragraphs 9.1.7 to 9.1.9 have been renumbered 9.1.9 to 9.1.11.

(Part only shown)

Table 24.9.1 Machinery emissions to air abatement plant: alarms and safeguards

Item	Alarm	Note
Chemical tank containment bund level	High	Tank outlet ~~quick closing~~ remote shut-off valve is to close automatically, *see* Note 5
Chemical tank containment drain line flow detection	Flow present	Tank outlet ~~quick closing~~ remote shut-off valve is to close automatically, *see* Note 5
Note 3. The process tank is any tank forming part of a wet abatement system flow loop or effluent tanks which receive bleed-off from the main flow loop, or such tanks not forming part of the system flow loop but which are essential for operation of the system, including those on exhaust gas recirculating installations, *see Pt 5, Ch 24, ~~7.1 General 7.1.9~~ 11.1 General 11.1.8*. Where low level can present a hazard, process tanks are also to have low level protection. Note 4. Where chemical substances are to be kept within a defined temperature range, alarms will be fitted, based on the allowable temperature range, *see Pt 5, Ch 24, 5.1 General 5.1.2 and Pt 5, Ch 24, 7.1 General ~~7.1.10~~ 7.1.9*.		

■ *Section 10*
Storage and use of chemicals

10.1 ~~Reductants used for selective catalytic reduction (SCR)~~ Sodium hydroxide solution

(*Existing paragraph 10.1.1 moved to become 10.3.1)*

10.1.1 Chemical storage tanks that contain sodium hydroxide (NaOH) solution (e.g. 50 per cent aqueous solution) are to comply with the requirements given in *Pt 5, Ch 24, 10.1 Sodium hydroxide solution 10.1.2* to *Pt 5, Ch 24, 10.1 Sodium hydroxide solution 10.1.18*.

10.1.2 ~~Storage tanks are to be arranged in accordance with *Pt 5, Ch 24, 5.1 General 5.1.5* and *Pt 5, Ch 24, 5.1 General 5.1.6*, so that any leakage will be contained and prevented from making contact with heated surfaces.~~ Chemical storage tanks are to be arranged to contain any leakage and to prevent any leakage from coming into contact with heated surfaces, e.g. use drip/spill trays leading to a closed tank, *see also, Pt 5, Ch 24, 5.1 General 5.1.5* and *Pt 5, Ch 24, 5.1 General 5.1.6*.

10.1.3 ~~Storage~~ Chemical storage tanks are to be protected from excessively high or low temperatures. Depending on the operational area of the ship, this may necessitate the fitting of heating and/or cooling systems in accordance with *Pt 5, Ch 24, 5.1 General 5.1.4*. ~~The physical conditions recommended by the applicable recognised standards (such as ISO 18611-3) are to be taken into account to avoid any impairment of urea solution during storage.~~

10.1.4 ~~The storage tanks may be located within the engine room.~~ The chemical storage tank location is to be in accordance with *Pt 5, Ch 24, 5.1 General 5.1.8*.

10.1.5 Where chemical storage tanks are integrated, the following are to be considered during the design and construction:

- These tanks shall be designed and constructed as integral part of the hull (e.g. double bottom, wing tanks);
- These tanks shall be coated with appropriate anti-corrosion coating or shall be made of adequate corrosion resistant materials and cannot be located adjacent to any fuel oil and fresh water tank;
- These tanks shall be designed and constructed in accordance with the structural requirements applicable to hull and primary support members described in *Pt 5, Ch 24, 5 Hull construction*; and
- These tanks shall be included in the ship's stability calculation.

10.1.6 The chemical storage tank piping is to meet the requirements of *Pt 5, Ch 24, 7.1 General 7.1.1*.

10.1.7 Pipes or other tank penetrations are to be provided with manual ~~closing~~ shut-off valves attached to the tank in accordance with ~~Pt 5, Ch 24, 7.1 General 7.1.3~~ *Pt 5, Ch 24, 7.1 General 7.1.3*.

10.1.8 The chemical storage tank piping and venting systems are to be independent of other ship service piping and/or systems as defined in *Pt 5, Ch 24, 5.1 General 5.1.9*.

10.1.9 The chemical storage tank piping systems are not to be located in accommodation, service spaces or control stations.

10.1.10 Piping systems, tanks and other components which will come into contact with the ~~urea solution~~ chemical are to be of a ~~suitable grade of non-combustible compatible material established to be suitable for the application~~ non-combustible material, suitable for the intended chemical and application.

10.1.11 Where chemical storage tanks are installed in closed compartments, the compartments are to be served by an effective mechanical ventilation system providing not less than six air changes per hour, which is independent from the ventilation system of accommodation, service spaces or control stations.

10.1.12 The ventilation system is to be capable of being controlled from outside the compartment and is to be in continuous operation except when the chemical storage tank is empty and has been thoroughly air purged.

10.1.13 The vent pipes of the chemical storage tank are to terminate in an area on the weather deck with no ignition hazard. The tank venting system is to be arranged to prevent entrance of water into the chemical storage tank.

10.1.14 The chemical storage tanks are to be arranged so that they can be emptied, purged and vented. ~~The drainage arrangements are to be independent of drainage arrangements of other systems and shall be capable of draining to a dedicated tank.~~

10.1.15 Where a chemical storage tank is located within an engine room, a separate ventilation system defined in *Pt 5, Ch 24, 10.1 ~~Reductants used for selective catalytic reduction (SCR)~~ Sodium hydroxide solution 10.1.8* is not required when the general ventilation system for the space is arranged so as to provide an effective movement of air in the vicinity of the storage tank, and is to be maintained in operation continuously except when the storage tank is empty and has been thoroughly air purged.

10.1.16 In the event of a ventilation failure, an audible and visual alarm ~~shall~~ is to be provided outside the compartment adjacent to each point of entry and inside the compartment, together with a warning notice requiring the use of such ventilation.

10.1.17 Each chemical storage tank is to be provided with alarms and safeguards in accordance with *Table 24.9.1 Machinery emissions to air abatement plant: alarms and safeguards*.

10.1.18 For the protection of ~~crew members~~ personnel, the ship is to have suitable personnel protective equipment on board such as, but not limited to, aprons, gloves, boots and safety goggles. Eyewash and safety showers are to be provided in locations where chemical contact is most likely to occur. The location (e.g. near chemical storage tank, loading area, etc.) and number of these eyewash stations and safety showers are to be derived from the detailed installation arrangements.

~~10.1.19 Reductant that uses aqueous ammonia (28 per cent or less concentration of ammonia) is to comply with the requirements given in *Pt 5, Ch 24, 10.1 Reductants used for selective catalytic reduction (SCR) 10.1.20* to *Pt 5, Ch 24, 10.1 Reductants used for selective catalytic reduction (SCR) 10.1.21*.~~

~~10.1.20 Aqueous ammonia is not to be used as a reductant in a SCR except where it can be demonstrated that it is not practicable to use urea solution as the reductant.~~

~~10.1.21 Where an application is made to use aqueous ammonia as the reductant, then the arrangements for its loading, carriage and use are to be derived from a risk-based analysis.~~

~~10.1.22 Reductant that uses anhydrous ammonia (99,5 per cent or greater concentration of ammonia by weight) is to comply with the requirements given in *Pt 5, Ch 24, 10.1 Reductants used for selective catalytic reduction (SCR) 10.1.23* to *Pt 5, Ch 24, 10.1 Reductants used for selective catalytic reduction (SCR) 10.1.25*.~~

~~10.1.23 Anhydrous ammonia is not to be used as a reductant in a SCR except where it can be demonstrated that it is not practicable to use urea solution as the reductant, and where the Flag Administration agrees to its use.~~

~~10.1.24 Where it is not practicable to use urea solution as the reductant, then it is also to be demonstrated that it is not practicable to use aqueous ammonia.~~

~~10.1.25 Where an application is made to use anhydrous ammonia as the reductant, then the arrangements for its loading, carriage and use are to be derived from a risk-based analysis.~~

10.2 Sodium bicarbonate

10.2.1 Sodium bicarbonate powder shall be stored in a compatible chemical storage tank in a cool, dry, well-ventilated area away from any incompatible materials such as acids.

10.2.2 Suitable personnel protection shall be provided in accordance with *Pt 5, Ch 24, 10.1 Sodium hydroxide solution 10.1.18*.

10.3 Ammonia solution

~~10.1.1~~ 10.3.1 ~~Storage~~ Chemical storage tanks that contain urea-based ammonia (e.g. 40 per cent urea with 60 per cent water solution), hereinafter referred to as urea solution, as a reductant, are to comply with the requirements given in *Pt 5, Ch 24, 10.1 ~~Reductants used for selective catalytic reduction (SCR)~~ Sodium hydroxide solution 10.1.2* to *Pt 5, Ch 24, 10.1 ~~Reductants used for selective catalytic reduction (SCR)~~ Sodium hydroxide solution 10.1.18*.

10.3.2 In addition to *Pt 5, Ch 24, 10.1 Sodium hydroxide solution 10.1.3*, the physical storage conditions recommended by applicable and recognised standards (such as ISO 18611-3) are to be taken into account to avoid any impairment of urea solution during storage.

10.3.3 Aqueous ammonia (with a concentration of 28 per cent of ammonia or less by weight) and anhydrous ammonia (with a concentration of 99,5 per cent of ammonia or greater by weight) are not to be used as a reductant unless it can be demonstrated that the use of urea solution is not practicable in which case the requirements for its safe loading, carriage and use are to be derived from a risk-based analysis. Agreement from Flag Administration shall also be required for anhydrous ammonia in addition to the risk-based analysis.

■ *Section 11*
SO_x emissions abatement plant

11.1 General

11.1.1 The requirements given in this Section are specific to SO_x emissions abatement plant and are in addition to the requirements given in *Pt 5, Ch 24, 1 General* to *Pt 5, Ch 24, 10 Storage and use of chemicals*.

11.1.2 In addition to the information and plans required in *Pt 5, Ch 24, 3 Information to be submitted*, the following are to be submitted for consideration:

- Details of the maximum and minimum ambient and sea-water temperatures within which the emissions abatement plant is designed to operate, and maximum and minimum ambient air temperature and humidity where relevant, i.e. where operation is temperature or humidity dependent.
- Details of the corrosivity of wash water for wet scrubbing systems, e.g. specific gravity, temperature, pH and presence of polluting substances such as oil content and turbidity.
- The Pitting Resistance Equivalent Number (PREN) is to be confirmed when stainless steels or nickel-based alloys are used for the wet scrubbing system containing wash water.
- For scrubber towers, a manufacturer's certificate for materials and welding details including procedure.
- Details on storage and use of sodium bicarbonate powder used in dry scrubbers, *see Pt 5, Ch 24, 10.2 Sodium bicarbonate*.

11.1.3 In addition to the requirements given in *Pt 5, Ch 24, 5 Hull construction* for the ship integration, the scrubber tower materials are to satisfy *Pt 5, Ch 24, 4.1 General 4.1.1* and welding is to be in accordance with *Chapter 12 Welding Qualifications* and *Chapter 13 Requirements for Welded Construction* of the *Rules for the Manufacture, Testing and Certification of Materials, July 2019*.

11.1.4 Where the mass distribution of a scrubber tower is such that the centre of mass differs significantly from the centre of gravity, due account of this is to be taken in the calculation of the forces and moments at the support positions, e.g. due to wave-induced motions, *see Pt 4, Ch 4, 5.3 Equipment supporting arrangements loads and permissible stresses 5.3.1*.

11.1.5 The integrity of the weather deck is to be maintained. Where items of a scrubber tower penetrate the weather deck and are intended to constitute the structural barrier to prevent the ingress of water to spaces below the freeboard deck, their structural strength is to be equivalent to the Rule requirements for this purpose. Otherwise, such items are to be enclosed in superstructures or deckhouses fully complying with the Rules.

11.1.6 Mounting arrangements are to take account of forces and moments generated at the supports. Mounting arrangements are to take account of thermal expansion and contraction.

11.1.7 Access is to be provided for inspection and checking of mountings, fittings, controls and pressure-relief devices.

11.1.8 Closed loop wet scrubbers are to have natural gravity fall drainage from the wet sump of the scrubber to the process tank or circulating pump suction, with the drain line dimensioned to accommodate 125 per cent of the maximum pumping capacity of the installed water pump(s). No valves are to be fitted to the drain line from the scrubber sump to the process tank, unless it can be demonstrated that the arrangements prevent the possibility of the scrubber filling with water and a reverse flow into the engine exhaust duct. Where a valve is fitted to this line, the system is to be protected as for the overboard discharge valve of an open loop system, in accordance with *Pt 5, Ch 24, 9.1 General 9.1.10*.

11.1.9 For open loop wet scrubbers, the overboard discharge valve and any other sea-water valves downstream of the scrubber are to be protected in accordance with *Pt 5, Ch 24, 9.1 General 9.1.10*. The sea suction valve(s) are also to have position indicators which are to give remote indication of valve position. The scrubber is to be mounted above the waterline under all operating conditions to prevent seawater ingress into the scrubber from the natural flow.

11.1.10 In order to prevent the reverse flow of water into engines, boilers and other machinery, wet scrubbing systems (open loop and closed loop) are to be fitted with an overflow line. This overflow is to be dimensioned to accommodate 125 per cent of maximum capacity of installed water pumps and is to have no impairment to flow. This overflow line is to be directed to the process tank in closed loop or hybrid installations and is to be directed overboard on open loop installations. The overboard discharge is to have an effective means of preventing reverse flow of sea-water. Alternative arrangements to prevent the risk of reverse flow are subject to special consideration.

11.1.11 Overboard discharge connections from scrubbers are to be positioned below the lowest operating waterline and are to be internally protected from effluent-induced corrosion.

11.1.12 The chemical storage tank requirements for NaOH solution stated in *Pt 5, Ch 24, 10.1 Sodium hydroxide solution* are applicable for closed loop wet scrubbers and hybrid scrubbers whereas the requirements for sodium bicarbonate power used in dry scrubbers stated in *Pt 5, Ch 24 10.2 Sodium bicarbonate* are applicable.

11.1.13 Where a scrubber tower is installed or intended to be installed, attention is drawn to the stability considerations and other applicable requirements of the National Authority with whom the ship is registered.

■ *Section 12*
NO$_x$ emissions abatement plant

12.1 General

12.1.1 The requirements given in *Pt 5, Ch 24, 1 General* to *Pt 5, Ch 24, 10 Storage and use of chemicals* are applicable to NO$_x$ emissions abatement plant unless otherwise stated.

12.1.2 The requirements for reductants used in SCR are given in *Pt 5, Ch 24, 10.3 Ammonia solution*.

Part 5, Chapter 25
Ballast Water Treatment System and Installation

■ *Section 9*
Electrotechnical Systems

9.1 General

9.1.4 Gas detection equipment is to be designed, installed and tested in accordance with ~~IEC 60079-29-1 *Explosive atmospheres – Part 29-1: Gas detectors – Performance requirements of detectors for flammable gases*~~ *IEC 60079-29-2: Explosive atmospheres Part 29-2: Gas detectors — Selection, installation, use and maintenance of detectors for flammable gases and oxygen*, and is to be suitable for the gases to be detected.

Part 6, Chapter 1
Control Engineering Systems

■ *Section 1*
General requirements

1.2 Documentation required for design review

1.2.1 The documentation described in *Pt 6, Ch 1, 1.2 Documentation required for design review 1.2.2* to *Pt 6, Ch 1, 1.2 Documentation required for design review* ~~*1.2.8*~~ *1.2.9* is to be submitted for design review.

(Part only shown)

1.2.3 Plans for the control, alarm, monitoring and safety systems of the following are to be submitted:

- Electric generating plant.
- Lithium battery system installations, *see also Pt 6, Ch 2, 1.2 Documentation required for design review 1.2.17*.
- ~~Waterjets~~ Water jets for propulsion purposes.

■ *Section 2*
Essential features for control, alarm and safety systems

2.8 Fire detection and fire alarm systems

2.8.1 Fire detection and fire alarm systems are to comply with *Chapter 9 – Fixed fire detection and fire alarm systems* of the *Fire Safety Systems Code* (FSS Code), SOLAS Chapter II-2 Part C *Regulation 7 - Detection and alarm* ~~of SOLAS Ch II-2, Part C~~ and ~~*Pt 6, Ch 1, 2.8 Fire detection alarm systems 2.8.2* to *Pt 6, Ch 1, 2.8 Fire detection alarm systems 2.8.23*~~ and the requirements in this Section ~~as applicable~~.

2.8.2 For cargo ships of less than 500 GT, the provisions of this Section are intended to apply to new ships, as far as reasonable and practicable, or as required by the relevant National Administration.

~~2.8.2~~ 2.8.3 Fire detection control units, indicating panels, detector heads, manual call points and short-circuit isolation units are to satisfy the requirements of the Type Approval Test Specification Number 1 given in LR's Type Approval System for an environmental categor~~ies~~y appropriate for the locations in which they are intended to operate. ~~For addressable systems, *see also*~~

~~*Pt 6, Ch 1, 2.10 Programmable electronic systems - General requirements*. FSS requires compliance of detectors with specific standards; refer to *Chapter 9 – Fixed fire detection and fire alarm systems* Section 2.3.1.2.~~

Existing paragraphs 2.8.3 and 2.8.5 have been deleted.

Existing paragraphs 2.8.6 to 2.8.8 have been renumbered 2.8.5 to 2.8.7.

Existing paragraphs 2.8.9 to 2.8.16 have been deleted.

~~2.8.17~~ 2.8.8 In passenger ships, the fixed fire detection and fire alarm systems are to be capable of remotely and individually identifying each detector and manually operated call point. ~~On other ships, indicating units are to denote, as a minimum, the section in which a detector or manually operated call point has operated. At least one indication unit is to be so located that it is easily accessible to responsible members of the crew. One indicating unit is to be located on the navigating bridge if the control panel is located in the central control station.~~

Existing paragraphs 2.8.18 to 2.8.22 have been deleted.

Existing paragraph 2.8.23 has been renumbered 2.8.9.

2.9 Fixed water-based local application fire-fighting systems

2.9.1 Where fixed water-based local application firefighting systems are installed in accordance with *SOLAS - International Convention for the Safety of Life at Sea* as amended Ch II-2, Pt C, Regulation 10, *5 Fire extinguishing arrangements in machinery spaces*, arrangements are to be in accordance with this sub-Section.

2.9.6 Alarms are to be initiated upon activation of a system and are to indicate the specific zone activated at the control panel. ~~Alarms are to be provided in each protected space, at an attended machinery control station and in the wheelhouse. The audible signal is to be distinguishable from other safety system signals.~~

2.9.12 The system's fire detection systems and control units ~~are to meet the performance criteria of SOLAS Ch II/C, Regulation 7 - Detection and alarm and~~ are to be ~~T~~type ~~A~~approved in accordance with *Test Specification Number 1* given in LR’s *Type Approval System* for an environmental category appropriate for the locations in which they are intended to operate.

Part 6, Chapter 2
Electrical Engineering

■ *Section 1*
General requirements

1.2 Documentation required for design review

1.2.1 The documentation described in *Pt 6, Ch 2, 1.2 Documentation required for design review 1.2.2* to *Pt 6, Ch 2, 1.2 Documentation required for design review* ~~*1.2.16*~~ *1.2.18* is to be submitted for design review.

1.2.17 **Lithium battery systems.** In addition to the plans and information required by *Pt 6, Ch 1, 1.2 Documentation required for design review 1.2.2*, the following information is also to be submitted:

(a) System functional description including all operating modes (i.e. charging, discharging, standby, backup, peak shaving, etc.), safety functions and their hierarchy, and expected battery system behaviour in case of malfunction.

(b) Technical description detailing how safety information from type testing has been considered in the actual installation design.

(c) Integration plan for the battery system with the vessel power distribution and charging arrangements.

(d) Line diagrams of the battery system control and power distribution, including switchgear, protective devices, control gear and emergency trip (E-Trip) as well as interfaces to external systems.

(e) A Failure Mode and Effects Analysis (FMEA) and mitigation strategy, which is to be carried out for the lithium battery system installation as a whole in accordance with IEC 60812*: Analysis techniques for system reliability – Procedure for failure mode and effects analysis (FMEA)*, or an equivalent and acceptable National or International Standard and the report and worksheets are to be submitted for consideration.

(f) Arrangement plans of any HVAC, ventilation, cooling system and drains for the battery space.

(g) Fire detection, alarm and extinguishing system (including portable fire-fighting appliances) plans for the battery space.

(h) A schedule of electrical equipment for use in the battery space and HVAC, ventilation and cooling system giving details of the appropriate type of protection for the temperature class and gas group of the potential gases. Copies of appropriate certification are to be submitted for consideration.

(i) Arrangement plans for electrical equipment showing cable routes associated with the battery system, power distribution and E-Trip.

(j) General arrangement plan showing hazardous zones for the battery space, including the HVAC, ventilation, cooling system and drains.

(k) Fire integrity plans for the battery space (including penetrations drawings), contiguous spaces and means of escape from the battery space.

1.2.18 For ships with hybrid electrical power systems as detailed in *Pt 6, Ch 2, 24 Hybrid electrical power systems* the following documentation is to be submitted for design review either uniquely or integrated with other submitted information.

Information required for all hybrid electrical power systems:

(a) A functional description of the electrical distribution systems and equipment that details compliance with the performance criteria and system capability and functionality under defined normal and reasonably foreseeable abnormal conditions including:
  i. degraded modes of operation;
  ii. load management and load sharing philosophy;
  iii. earthing philosophy;
  iv. system electrical protection philosophy;
  v. system stability; and
  vi. converter switching actions.

(b) Definition of system performance targets (*see Pt 6, Ch 2, 24.5 Hybrid electrical power system performance - System performance targets*);
(c) Definition of dependability principles (*see Pt 6, Ch 2, 24.6 Hybrid electrical power system performance - Dependability principles*);
(d) Calculations supporting the size and rating of stores of electrical energy (*see Pt 6, Ch 2, 24.6 Hybrid electrical power system performance - Dependability principles 24.6.7*);
(e) Risk assessment in support of there being no dedicated emergency source of power when this is proposed (*see Pt 6, Ch 2, 24.8 Hybrid electrical power system performance - Emergency source of electrical power 24.8.2*);
(f) Details of any arrangements for external sources of power to charge onboard stores of electrical energy (see *Pt 6, Ch 2, 24.9 Hybrid electrical power system performance – External source of electrical power 24.9.4*);
(g) Voltage rate of rise times for pulse width modulated converters (see *Pt 6, Ch 2, 24.11 Hybrid electrical power system components - Source of electrical power 24.11.6*);
(h) Risk assessment in support of active fault current limiting devices when this is proposed (*see Pt 6, Ch 2, 24.15 Hybrid electrical power system components - Distribution system 24.15.11*);
(i) Technical description of energy management functionality (*see Pt 6, Ch 2, 24.16 Hybrid electrical power system components - Energy management 24.16.8*);
(j) Technical description of arrangements for power quality monitoring (*see Pt 6, Ch 2, 24.17 Transversal requirements 24.17.6*);
(k) Power system integration procedure (*see Pt 6, Ch 2, 24.18 Power system development and integration - General*);
(l) System operational concept (*see Pt 6, Ch 2, 24.19 Power system development and integration - System operational concept*);
(m) Technical description of operating modes (*see Pt 6, Ch 2, 24.20 Power system development and integration - Operating modes*);
(n) Validated specifications of system components (*see Pt 6, Ch 2, 24.22 Power system development and integration - System components*);
(o) Results of energy flow analysis (*see Pt 6, Ch 2, 24.23 Power system development and integration - Energy flows*);
(p) Results of power system analysis (*see Pt 6, Ch 2, 24.24 Power system development and integration - Power system analysis*);
(q) Definition of safety functions (*see Pt 6, Ch 2, 24.25 Power system development and integration - Safety functions*);
(r) System FMEA (*see Pt 6, Ch 2, 24.27 Power system development and integration - System Failure Modes and Effects Analysis (FMEA)*);
(s) System operating instructions (*see Pt 6, Ch 2, 24.28 Power system development and integration - Operating instructions*);
(t) Description and verification of ship-specific Operator training needs (*see Pt 6, Ch 2, 24.29 Power system development and integration - Operator training*); and
(u) Description of through-life system integration roles and responsibilities (*see Pt 6, Ch 2, 24.30 Power system development and integration - Through-life accountability*).

Additional information required for Hybrid Power (+) notation systems:

(a) Dependability assessment (*see Pt 6, Ch 2, 24.6 Hybrid electrical power system performance - Dependability principles*);
(b) Technical description of arrangements for automatic earth fault location (*see Pt 6, Ch 2, 24.15 Hybrid electrical power system components - Distribution system 24.15.14*);
(c) Technical description of arrangements for power quality degradation detection (*see Pt 6, Ch 2, 24.15 Hybrid electrical power system components - Distribution system 24.15.23*);
(d) Technical description of additional energy management functionality (*see Pt 6, Ch 2, 24.16 Hybrid electrical power system components - Energy management 24.16.8*);
(e) Validation, verification and results of energy flow simulation (*see Pt 6, Ch 2, 24.23 Power system development and integration - Energy flows 24.23.3*);
(f) Validation, verification and results of power system simulation (*see Pt 6, Ch 2, 24.24 Power system development and integration - Power system analysis 24.24.4*);
(g) Risk assessment study when required (*see Pt 6, Ch 2, 24.26 Power system development and integration - Risk assessment*); and

(h) Evidence of ship-specific Operator training verification (*see Pt 6, Ch 2, 24.29 Power system development and integration - Operator training 24.29.2*).

1.3 Documentation required for supporting evidence

1.3.1 The documentation and particulars in *Pt 6, Ch 2, 1.3 Documentation required for supporting evidence 1.3.2* to *Pt 6, Ch 2, 1.3 Documentation required for supporting evidence ~~1.3.5~~ 1.3.11* are to be submitted as supporting evidence.

1.3.11 **Lithium battery systems.** In addition to the plans and information required by *Pt 6, Ch 2, 1.2 Documentation required for design review 1.2.17*, the following information is also to be submitted:

(a) Document outlining the operational limitations for the battery system.
(b) Operation, maintenance and training manuals for the battery system are to be kept on board including:
    (i) Manual that describes the standard operating, maintenance and emergency procedures for the system;
    (ii) Testing procedures including Annual Survey test requirements (*see Pt 6, Ch 2, 21 Testing and trials*, *Table 2.21.3 Test requirements on lithium battery systems*);
    (iii) Through-life management plan for the battery system, including disposal.

1.6 Definitions

1.6.18 A **'**secondary lithium cell' is a cell where electrical energy is derived from the insertion/extraction reactions of lithium ions or oxidation/reduction of lithium between the negative electrode and the positive electrode. These may be combined in 'cell blocks' consisting of a group of cells connected together in a parallel configuration.

1.6.19 A **'**battery module' is an energy storage device comprising one or more electrically connected cells or cell blocks. The battery module can include protective and monitoring devices.

1.6.20 A **'**battery pack' is an energy storage device comprising one or more electrically connected cells, cell blocks or modules. The battery pack can include protective devices and control and monitoring systems which communicate with the battery management system.

1.6.21 A 'battery management system (BMS)' is an electronic system which monitors and manages the state of a cell, battery module or battery pack in order to maintain the battery system in a safe operating state and protect against overcharging, overcurrent and overheating and communicates with an external charge/discharger controller.

1.6.22 A **'**lithium battery system' is a system comprising one or more lithium battery modules or packs incorporated in a fixed installation together with means of isolation, a cooling system (if provided) and has an associated BMS.

1.6.23 'State of charge (SOC)' is the available capacity in a battery expressed as a percentage of rated capacity.

1.6.24 'State of health (SOH)' reflects the general condition of a battery expressed as a percentage of its ability to deliver the specified performance compared with that of a new battery.

1.6.25 'Battery space' is the space or compartment in which a battery is installed.

■ *Section 9*
Rotating machines

9.1 General requirements

9.1.1 ~~Rotating machines are to comply with the relevant parts of IEC 60092: *Electrical installations in ships* , or an acceptable and relevant National Standard, and the requirements of this Section.~~ In addition to the requirements of this Section, rotating machines are to comply with the relevant requirements of the following standards, amended where necessary for ambient temperature, *see Pt 6, Ch 2, 1.9 Ambient reference and operating conditions*:

(a) IEC 60034: *Rotating electrical machines* (all parts); and
(b) IEC 60092: *Electrical installations in ships* (all parts); or
(c) an alternative International or National Standard acceptable to LR.

■ *Section 12*
Batteries

12.1 General

12.1.1 The requirements of this Section apply to aqueous and non-aqueous permanently installed secondary batteries of the vented and valve-~~-~~regulated sealed type such that the following goal and functional requirements are achieved:

- **Goal**

  Safe energy storage and dependable supply of power to consumers.
- **Functional requirements**

Reasonably foreseeable hazards external to the battery shall be identified and managed.
Reasonably foreseeable hazards internal within the battery shall be identified and managed.

12.1.4 The following Sections apply to lead acid, ~~and~~ nickel cadmium and lithium cell chemistries. Where other chemistries are to be used, the LR ~~ShipRight Procedure~~ *ShipRight Procedure Assessment of Risk Based Designs* is to be followed.

12.1.5 Lithium battery systems are to satisfy the requirements of LR's *Type Approval System Test Specification Number 5 (2019)*. Alternative arrangements may be subject to special consideration.

12.1.6 Lithium battery management systems are to satisfy the requirements of LR's *Type Approval System Test Specification Number 1 (2018)*. Alternative arrangements may be subject to special consideration.

12.1.7 Where the lithium battery total system installation is less than 20 kWh then it is to be housed in a gastight steel enclosure with a gastight ventilation duct leading to a safe space on open deck and is to be suitable for withstanding the temperatures and pressures generated in the worst case thermal runaway condition. The battery system is to satisfy the requirements of LR's *Type Approval System Test Specification Number 5 (2019)*, or an equivalent and acceptable National or International Standard, amended where necessary for a battery space ambient temperature of 45°C. Alternative arrangements will be subject to special consideration.

12.1.8 The following Sections apply to lithium battery system installations of a total system capacity of 20 kWh or greater and are in addition to those applicable in other Parts of these Rules:

- *Pt 6, Ch 2, 12.1 General 12.1.9*;
- *Pt 6, Ch 2, 12.2 Design and construction 12.2.2* to *Pt 6, Ch 2, 12.2 Design and construction 12.2.6*;
- *Pt 6, Ch 2, 12.3 Location 12.3.12*;
- *Pt 6, Ch 2, 12.4 Installation 12.4.5* to *Pt 6, Ch 2, 12.4 Installation 12.4.11*;
- *Pt 6, Ch 2, 12.5 Thermal management and ventilation 12.5.8* and *Pt 6, Ch 2, 12.5 Thermal management and ventilation 12.5.12*;
- *Pt 6, Ch 2, 21.1 Testing 21.1.6.*

12.1.9 For lithium battery system installations of nominal voltages exceeding 1500 V d.c. the LR *ShipRight Procedure Assessment of Risk Based Designs* is to be followed.

12.1.10 Additional requirements may be imposed by the National Administration with which the ship is registered and/or by the Administration within whose territorial jurisdiction the ship is intended to operate. Where any such requirements exist, in the event of a conflict with the requirements herein the requirements of the National Administration will generally take precedence.

12.1.11 Integration of a lithium battery system that satisfies a ship's main power demand into the ship's electrical power system is to be in accordance with *Pt 6, Ch 2, 24 Hybrid electrical power systems*.

12.2 Design and c~~C~~onstruction

12.2.2 A Failure Mode and Effects Analysis (FMEA) is to be carried out for the lithium battery system installation and is to consider the effects of failure upon safety and dependability of the lithium battery system installation, taking account of reasonably foreseeable internal and external failures such that the goal and functional requirements of *Pt 6, Ch 2, 12.1 General 12.1.1* are achieved and is to include but is not limited to the following:
(a) overpressure, fire and explosion;
(b) electrical short circuit due to leakage of cell electrolyte or mechanical impact;
(c) venting out flammable and toxic gases;
(d) rupture of the casing of cell, battery module, battery pack or battery system with exposure of internal components; and
(e) ingress of water into the battery space from cooling system leak, fire suppression system release and/or adjacent areas.
No single failure is to directly result in conditions more arduous than those under which the battery system has been type tested or in the hidden loss of any monitoring and control, alarm, or safety function (either automatic or manual) on which the battery system installation depends for its safe operation.

12.2.3 The casing of a lithium cell and/or battery modules is to incorporate a pressure relief function(s) that will prevent overpressure, rupture or explosion of the battery module enclosure (*see Pt 6, Ch 2, 21 Testing and trials*).

12.2.4 The lithium battery management system is to continuously monitor the condition of cells, battery modules or battery packs and to maintain them within their specified safe operating region. As a minimum the alarms and safeguards as indicated in *Table 2.12.1 Lithium battery system: alarms and safeguards* are to be provided:

Table 2.12.1 Lithium battery system: alarms and safeguards

Item	Alarm	Note
Cell voltage*	High	Automatic termination of the cell charge current. *See* Notes 1 and 5
	Low	Per cell. Automatic prevention of cell discharge. *See*

		Notes 2 and 5
Cell temperature*	1st stage high	Per sensor. *See* Notes 4 and 5
	2nd stage high	Per sensor. Automatic shutdown of battery system. *See* Notes 4 and 5
	Low	Automatic charge and discharge current limitation. *See* Notes 3 and 4
Charge current of the battery cells	High	Automatic reduction of charge/discharge current. *See* Note 3
Communication failure between battery management system and external charge controller system	Failure	Automatic shutdown of battery system *See* Note 6
Battery management system	Failure	Automatic shutdown of battery system
Temperature sensor	Failure	Automatic shutdown of battery system
Voltage sensor	Failure	Automatic shutdown of battery system
Emergency trip*	Active	Automatic shutdown of battery system. *See* Note 5
Insulation resistance	Low	-

Note 1. Cell voltage is to be maintained below the cell manufacturer specified upper limit charge voltage.

Note 2. Cell voltage is to be maintained above the cell manufacturer specified lower limit discharge voltage.

Note 3. Cell charge/discharge current is to be controlled within cell manufacturer specified current limits.

Note 4. Cell temperature is to be controlled within the cell manufacturer specified temperature limits.

Note 5. For lithium batteries used as an emergency source of power, only items marked * are to initiate automatic shutdown.

Note 6. For lithium batteries used as an emergency source of power, communication failure is to automatically stop and prevent charging.

Note 7. Automatic shutdown of battery system includes termination of battery charging and discharging and disconnection from electrical distribution network.

12.2.5 A fully independent hard-wired means to disconnect the battery system in an emergency from power distribution is to be provided. This emergency trip is to be located outside of the battery space and situated such that it will remain accessible in the event of an emergency inside the battery space and is to initiate an audible and visual alarm at the relevant control stations to advise duty personnel of the emergency condition.

12.2.6 For lithium battery system installations the following is to be measured and displayed at control stations relevant to the system in which the battery system is installed:

(a) State of charge (SOC) and state of health (SOH) are to be displayed at relevant control stations and on the navigating bridge.
(b) System alarms are to be displayed at relevant control stations and at least a common alarm displayed on the navigating bridge.

12.3 Location

12.3.12 The lithium battery space is to be separate from other spaces and compartments, is not to be located forward of the collision bulkhead and is not to be contiguous to the boundaries of machinery spaces of Category A or those spaces containing the main source of electrical power, associated transforming equipment (if any) or the main switchboard. The boundaries of the lithium battery space are to be part of a vessel structure or enclosures and provided with ‘A-60’ insulation of the bulkhead unless the space is adjacent to spaces of negligible fire risk such as cofferdams, void spaces or similar, in which case consideration may be given to reducing the insulation to ‘A-0’. Penetrations through these boundaries are to be protected to the same fire protection standard. Special consideration will be made for a ship not built of steel or equivalent material. All other safety systems within the lithium battery spaces are to be in accordance with the requirements of this Section or, if not made explicit, at least equivalent to those of a machinery space of Category A.

12.4 Installation

12.4.5 Battery systems are to be installed in accordance with manufacturer’s recommendations taking account of the results of the FMEA study.

12.4.6 The lithium battery space and the crates, trays, boxes, shelves and other structural parts therein are to be designed and constructed such that the structural integrity of the battery space will not be compromised in the event of a lithium fire.

12.4.7 The lithium battery space is to be fitted with suitable fixed detectors in accordance with manufacturer’s recommendations and which are capable of providing early identification of a fire or thermal runaway condition. Early identification is to include high cell temperature or detection of electrolyte solvent vapours and a combination of smoke and heat detectors. When activated, the fire detection system is to initiate an alarm to the relevant control stations and on the navigating bridge and is to initiate the automatic isolation of electric systems within the lithium battery space, except as described below, and activate the fixed fire-fighting system.

12.4.8 In the event that a fire or thermal runaway condition is identified, the battery monitoring system is to initiate protective features such as automatic safe isolation of the batteries. Ventilation necessary for extraction of gasses, active cooling systems, and thermal/safety monitoring and alarm are to be continued prior to, during and after an overheating or fire event. Failure of the monitoring system is to be alarmed to the ship's safety system and is to result in the battery system automatically reverting to a defined safe state.

12.4.9 An appropriate water-based fixed fire-fighting system in accordance with SOLAS II-2, Part C, Regulation 10.4.1.1.3 and the manufacturer's recommendation is to be provided for the lithium battery space. The fixed fire-fighting system is to be suitable for heat removal, boundary cooling and/or extinguishing for the duration that the heat and/or gas release are present. Fixed fire-fighting systems using a medium other than water which provide equivalent heat removal, boundary cooling and/or extinguishing for the duration that the heat and/or gas release is present can be taken into consideration provided that appropriate fire tests have been conducted. In particular, the fire-extinguishing media are to be chosen as appropriate for the specific type and characteristics of fire foreseen.

12.4.10 The fixed fire-fighting control system is to be located outside the battery space, be activated automatically and be capable of manual activation. In addition to the fixed fire-fighting system, the battery space is to be provided with a minimum of two (2) portable and suitable fire-extinguishers located outside the space at or near the entrance(s). The number and position of hydrants are to be such that at least two jets of water not emanating from the same hydrant, each from a single length of hose, can reach any part of the lithium battery space. Such hydrants are to be positioned in close proximity to the lithium battery space. Any part of the fire-fighting system which crosses through the lithium battery space without serving it is to be avoided.

12.4.11 The fire detection and alarm systems are to be in accordance with the recommendations of the battery manufacturer and the following sub-Sections of these Rules:
- *Pt 6, Ch 1, 2.8 Fire detection alarm systems*;
- *Pt 6, Ch 2, 17.1 Fire detection and alarm systems;*

12.4.12 The technical description detailed in *Pt 6, Ch 2, 1.2 Documentation required for design review 1.2.17(b)* is to consider the actual battery system installation and its integration into the ship, including but not limited to the following:
- arrangement of battery compartment (location, including fire risk of adjacent spaces/compartments, fire burden from equipment other than batteries, heat sources, etc.);
- temperature control arrangements for the battery space and their contribution to system safety;
- ventilation arrangements to prevent concentrations of gasses within the space in case of uncontrolled thermal runaway;
- hazardous area(s) requirements;
- reasonable gas tightness of ventilation ducting;
- fire integrity of the space;
- the use of fire extinguishing arrangements for cooling in the case of uncontrolled thermal runaway.

The FMEA referenced in *Pt 6, Ch 2, 12.2 Design and construction 12.2.2* should address any additional failure modes identified during the preparation of this technical description.

12.4.13 The lithium battery space is to be provided with two means of escape, at least one independent of any watertight door and leading to a safe position outside the space. One of the escapes is to be suitable for the passage of a stretcher. At each entrance/exit an emergency escape breathing device (EEBD) is to be provided. Where the maximum travel distance to the door within the lithium battery space is less than 5 m, a single means of escape is acceptable. The lithium battery space is not to be considered as part of an escape route (primary or secondary) from any other accommodation, control, service space, machinery space of Category 'A' and high fire risk area such as a garage, paint store, etc.

12.5 Thermal management and v~~V~~entilation

12.5.8 Ventilating fans for battery compartments are to be so constructed and be of material such as to minimise risk of sparking in the event of the impeller touching the casing, and are to be suitable for the potentially hazardous and corrosive gases produced in a thermal runaway condition. Non-metallic~~/~~ impellers are to be of an anti-static material.

12.5.12 Thermal management of the lithium battery space is to be assessed, including the criticality of any cooling systems required to ensure reliable operation and to prevent thermal runaway within the marine environment. *See also Pt 6, Ch 1, 1.4 Control, alarm and safety equipment 1.4.3*.

■ *Section 17*
Fire safety systems

17.1 Fire detection and fire alarm systems

17.1.1 Fire detection and fire alarm systems are to comply with Chapter 9 of the *Fire Safety Systems Code* (FSS Code) ~~and *Pt 6, Ch 2, 17.1 Fire detection and alarm systems 17.1.2*~~ , SOLAS Chapter II-2, Part C, *Regulation 7 - Detection and alarm* and the requirements in this Section.

17.1.2 ~~Fire detection and alarm systems are to be provided with at least two power supplies from the main and emergency switchboards and automatic changeover facilities as directed by *FSS Code - Fire Safety Systems – Resolution MSC.98(73)* 2.2.1. Failure of any power supply is to operate an audible and visual alarm in accordance with the *Code on Alerts and Indicators, 2009*~~ In passenger ships, a section of detectors and manually operated call points shall not be situated in more than one main vertical or horizontal zone, except on cabin balconies.

Existing paragraphs 17.1.3 to 17.1.8 have been deleted.

17.2 Automatic ~~sprinkler system~~ Sprinkler, fire detection and fire alarm systems

17.2.1 ~~Any electrically driven power pump, provided solely for the purpose of continuing automatically the discharge of water from the sprinklers, is to be brought into action automatically by the pressure drop in the system before the standing fresh water charge in the pressure tank is completely exhausted~~ Automatic sprinkler, fire detection and fire alarm systems are to comply with *Chapter 8 – Automatic Sprinkler, Fire Detection and Alarm Systems* of the FSS Code. *See also Pt 6, Ch 2, 1.16 Operations under fire conditions*.

Existing paragraphs 17.2.2 to 17.2.4 have been deleted.

17.3 Fixed water-based local application fire-fighting systems

17.3.1 ~~Where fixed water-based local application fire-fighting system pressure sources are reliant on external power they need only be supplied by the main source of electrical power~~ Fixed water-based local application fire-fighting systems are to comply with SOLAS, Chapter II-2, Part C, *Regulation 10 - Fire fighting*, Section 5.6 and *Pt 6, Ch 2, 17.3 Fixed water-based local application fire-fighting systems 17.3.2* to *Pt 6, Ch 2, 17.3 Fixed water-based local application fire-fighting systems 17.3.13*.

Existing paragraph 17.3.5 has been deleted.

~~17.3.6~~ 17.3.5 As far as is practicable, electrical and electronic equipment is not to be located within protected areas or adjacent areas. ~~The system pump, its electrical motor and the sea valve if any, may be in a protected space provided that they are outside areas where water or spray may extend.~~

Existing paragraphs 17.3.7 to 17.3.14 have been renumbered to 17.3.6 to 17.3.13.

17.5 ~~Refrigerated liquid carbon dioxide systems~~ Fixed gas fire-extinguishing systems

17.5.1 Where there are electrically operated fixed gas fire-extinguishing systems, they are to comply with Chapter 5 of the FSS Code.

Existing paragraphs 17.5.1 and 17.5.2 have been renumbered 17.5.2 and 17.5.3.

17.5.4 Where it is required that alarms be provided to warn of the release of a fire-extinguishing medium, and these are electrically operated;

- they are to be provided with an emergency source of electrical power, as required by *Pt 6, Ch 2, 3.3 Emergency source of electrical power in passenger ships* or *Pt 6, Ch 2, 3.4 Emergency source of electrical power in cargo ships*;
- also connected to the main source of electrical power, with automatic changeover facilities located in, or adjacent to, the fire-extinguishing media release panel, *see also Pt 6, Ch 2, 1.14 Alarms*; and
- Failure of any power supply is to operate an audible and visual alarm, *see also Pt 6, Ch 2, 1.14 Alarms* and *Pt 6, Ch 2, 1.16 Operation under fire conditions*

17.5.5 The opening of the fire-extinguishing media control cabinet door, or panel, for any purpose other than for the release of the fire-extinguishing media, is not to cause the loss of any essential services, *see Pt 6, Ch 2, 1.6 Definitions 1.6.1*.

17.6 Fire safety stops

17.6.1 In order to limit the fire growth potential in every space of the ship, means for controlling the air supply to the spaces and flammable liquids within the spaces are to ~~be provided~~ comply with SOLAS Chapter II-2, Part B, *Regulation 5 - Fire growth potential*.

Existing paragraphs 17.6.2 to 17.6.4 have been deleted.

~~17.6.5~~ 17.6.2 ~~In passenger ships, the means of stopping machinery ventilation fans required by *Pt 6, Ch 2, 17.6 Fire safety stops 17.6.2* is to be located at the central control station which is to have safe access from the open deck. The central control station is to be provided with ventilation fan OFF status indications together with a means for restarting the ventilation fans.~~ In passenger ships, the control and indication arrangements at the central control station are to comply with SOLAS Chapter II-2, Part A, *Regulation 3 - Definitions*.

Existing paragraphs 17.6.6 to 17.6.10 have been renumbered to 17.6.3 to 17.6.7.

17.8 Fire dampers

17.8.1 The electrical power required for the control and indication circuits of fire dampers is to be supplied from the emergency source of electrical power, *see also Pt 6, Ch 2, 1.16 Operation under fire conditions*.

Existing sub-Section 17.9 has been deleted.

~~17.10~~ 17.9 Safety centre on passenger ships

~~17.10.1~~ 17.9.1 ~~Passenger ship safety centres required by SOLAS Ch II/2, *Regulation 23 - Special requirements for ro-ro passenger ships* to provide a control station dedicated to assist with the management of emergency situations are to satisfy the requirements of this sub-Section~~ Safety centres on passenger ships are to comply with SOLAS Chapter II-2, Part G, *Regulation 23 – Safety centre on passenger ships*.

Existing paragraph 17.10.2 has been deleted.

Existing paragraphs 17.10.3 and 17.10.4 have been renumbered 17.9.2 and 17.9.3.

~~17.11~~ 17.10 Electrically powered air compressors for breathing air cylinders

~~17.11.1~~17.10.1 In passenger ships carrying more than 36 passengers where electrically powered air compressors are installed they are to be in accordance with SOLAS, Chapter II-2, Part C, *Regulation 10 - ~~Construction of watertight bulkheads~~ Fire fighting*, Section 10.2.6.1.

■ *Section 21*
Testing and trials

21.1 Testing

21.1.6 Tests at the manufacturers' works and trials after installation on board are to include such tests necessary to demonstrate, to the Surveyor's satisfaction, the suitability and safety of the lithium battery system for its intended duty and location. As a minimum, the tests listed in *Table 2.21.3 Test requirements on lithium battery systems* are required:

Table 2.21.3 Test requirements on lithium battery systems

Item	Tests	Trials
Discharge performance validation	X	
Capacity validation test *	X	X
Internal d.c. resistance test	X	
Overcharge control test	X	
Cell balancing functional test	X	
Sensor failures test	X	
SOC validation test *	X	X
SOH validation test *	X	X
High voltage test	X	
Insulation resistance test	X	
Emergency trip functional test *	X	X
Over-temperature protection test	X	X
Over-voltage protection test	X	X
Under-voltage protection test	X	X
Communication failure between BMS and external charge control system test *	X	X
Pressure relief valve test	X	
Additional safety functions tests and trials of the battery management system	X	X
Note. Items marked * are required to be tested annually.		

■ *Section 24*

Hybrid electrical power systems

24.1 Scope

24.1.1 The requirements of this Section are applicable to ships having a main source of electrical power which is provided by hybrid electrical power generation and distribution systems within which the main electrical power demand is supplied by two or more different types of power source or by stored electrical energy.

24.1.2 These requirements apply to the design, construction and integration of hybrid electrical power systems, their sub-systems, machinery and equipment.

24.1.3 These requirements apply to hybrid electrical power systems which provide the main source of electrical power and exceptionally, where permitted by the National Administration, the emergency source of electrical power.

24.1.4 In addition to these requirements National Administrations may impose further requirements. Where such requirements conflict with these requirements, the requirements of the National Administration will take precedence.

24.1.5 These requirements are additional to the applicable requirements of the *Rules and Regulations for the Classification of Ships, July 2019*.

24.2 Characters of classification and class notations (machinery special features)

24.2.1 Ships complying with the mandatory requirements of this Section will be assigned the **Hybrid Power** machinery special features notation.

24.2.2 Ships complying with both the mandatory requirements and the additional optional requirements of this Section will be assigned the **Hybrid Power (+)** machinery special features notation.

24.2.3 **Hybrid Power**: Assigned to ships with an electrical power system including a combination of two or more different types of power source or utilising stored electrical energy to satisfy the ship's main power demand. The system and its component parts are in accordance with the existing applicable requirements of the Rules and the requirements of *Pt 6, Ch 2, 24 Hybrid electrical power systems*.

24.2.4 **Hybrid Power (+)**: Assigned to ships meeting the requirements for **Hybrid Power** and the additional optional requirements for **Hybrid Power (+)** specified within *Pt 6, Ch 2, 24 Hybrid electrical power systems*. The additional optional requirements aim to provide for enhanced performance of the electrical power system achieved through the consideration of system simulation, system integration and dependability of the electrical power system during normal or reasonably foreseeable abnormal operation.

24.3 Definitions

24.3.1 Hybrid electrical power system: A ship's electrical power system comprising sources, stores, consumers and distribution of electrical power together with their associated controls within which electrical power is provided by two or more different types of power source or utilising stored electrical energy to satisfy the ship's main power demand. This definition is independent of:
(a) the type of distribution system (see *Pt 6, Ch 2, 24.3 Definitions 24.3.8*);
(b) the types and ratings of source, their physical location and time duration of connection to the ship's power system;
(c) the types of store;
(d) the types of connected consumer; and
(e) the presence or otherwise of electric propulsion.

24.3.2 Reasonably foreseeable abnormal condition: A reasonably foreseeable abnormal condition is an operation, event, incident or failure that:
(a) has happened and could happen again;
(b) has not happened but is considered possible. Where the likelihood is considered extremely unlikely or the consequences are trivial, and no further prevention or mitigation action is to be taken, then this is to be justified; and
(c) is planned for (e.g. emergency actions cover such a situation, maintenance is undertaken to prevent it).

They should be identified by:
(a) using analysis processes that are capable of revealing abnormal conditions;
(b) employing a mix of personnel including designers, Operators, persons who carry out maintenance and competent safety/risk professionals with relevant domain knowledge and understanding to apply the processes;
(c) referencing relevant events and historic data; and
(d) documenting the results of the analysis.

24.3.3 Source of electrical power: A source of electrical power produces electrical power from an energy source such that its output may be connected to ship's electrical power distribution system (*see Figure 2.24.1 Source of electrical power*). It includes:

(a) Dedicated conversion where conversion is the changing of an output with respect to its input and may include change of form (e.g. a.c. to d.c. or d.c. to a.c.), change in magnitude (e.g. of voltage, current or frequency), change in phase or change in reference (e.g. through galvanic isolation);
(b) Management systems perform monitoring, control, protection and safety functions that are likely to be connected to higher level ship wide supervisory systems: and
(c) Systems providing control, alarm, monitoring and safety functions such as control panel, governor, automatic voltage regulator (AVR) and emergency shutdown (ESD) system for a reciprocating engine or gas turbine generator.

This definition of source of electrical power is independent of:
(a) the type of source (e.g. rotating generator, waste heat recovery system, wind generator, solar panel, fuel cell, photovoltaic array);
(b) the type of distribution system (*see Pt 6, Ch 2, 24.3 Definitions 24.3.8*); and
(c) the application of the source (e.g. main/additional/emergency/transitional source of power).

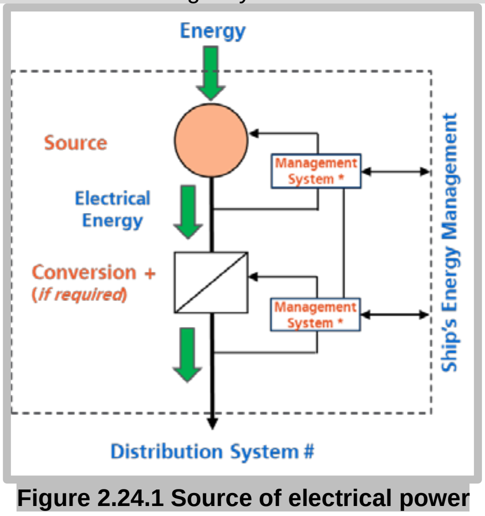


Figure 2.24.1 Source of electrical power

24.3.4 Additional source of electrical power: An additional source of power is a source of electrical power not forming part of the ship's main source of power that is rated to supply a proportion of the ship's main power demand at any time either continuously or for an accepted period of time, e.g. an energy storage device or a power take-off that is not rated for or capable of permanent operation.

24.3.5 Store of electrical energy: A store of electrical energy receives, stores and discharges energy through a single point of common coupling with the distribution system (*see* in *Figure 2.24.2 Store of electrical energy*). It includes management systems and any required dedicated conversion as defined in *Pt 6, Ch 2, 24.3 Definitions 24.3.3*. This definition is independent of:
(a) the method of energy storage;
(b) the type of store (e.g. battery, capacitor);
(c) the type of distribution system (*see Pt 6, Ch 2, 24.3 Definitions 24.3.8*); and
(d) the application of the store (e.g. power source, load smoothing, peak shaving, dynamic response, power backup).

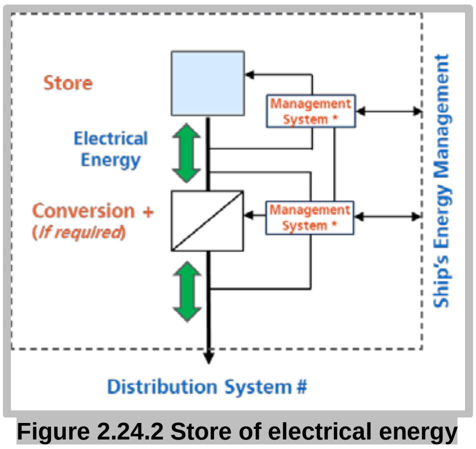


Figure 2.24.2 Store of electrical energy

24.3.6 Consumer of electrical power: A consumer of electrical power takes its input from the distribution system and delivers useful work through its associated load (*see Figure 2.24.3 Consumer of electrical power*). It includes management systems and any required dedicated conversion as defined in *Pt 6, Ch 2, 24.3 Definitions 24.3.3*. Consumers are present in any electrical power system and are not unique to hybrid electrical power systems. The definition is provided here for completeness. This definition is independent of:
(a) the type of load or the purpose for which it is installed; and
(b) the type or physical form of distribution system.

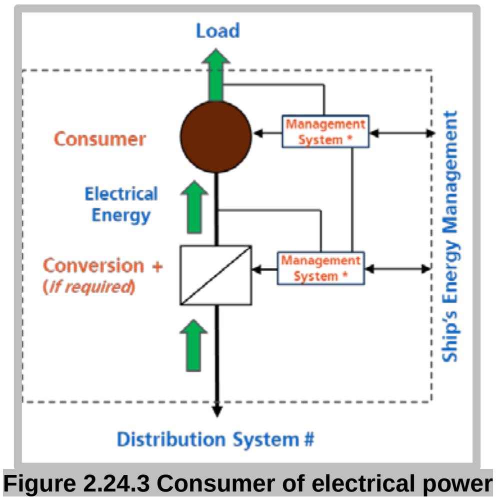


Figure 2.24.3 Consumer of electrical power

24.3.7 Combined sources/stores/consumers of electrical power: A combined source/store/consumer of electrical power provides multiple functions as defined in *Pt 6, Ch 2, 24.3 Definitions 24.3.3* to *Pt 6, Ch 2, 24.3 Definitions 24.3.6* in a single functional arrangement (some examples are shown in *Figure 2.24.4 Combined source and consumer of electrical power to Figure 2.24.7 Combined store of electrical energy and source and consumer of electrical power*). They include management systems and any required dedicated conversion as defined in *Pt 6, Ch 2, 24.3 Definitions 24.3.3*.

Figure 2.24.4 Combined source and consumer of electrical power to *Figure 2.24.7 Combined store of electrical energy and source and consumer of electrical power* depict building blocks that may be encountered in a hybrid electrical power system. These do not represent complete systems, are provided for illustration purposes only and are not exhaustive with further permutations being viable.

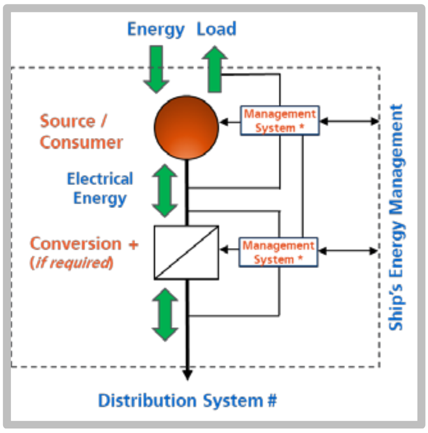


Figure 2.24.4 Combined source and consumer of electrical power

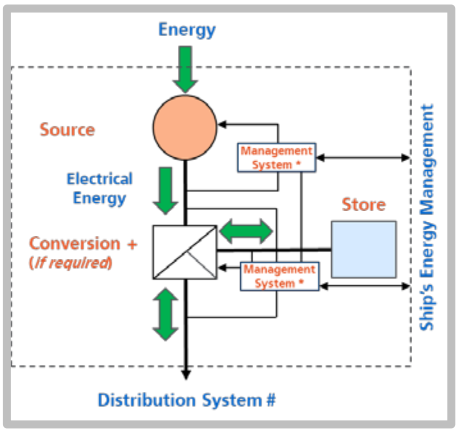


Figure 2.24.5 Combined source of electrical power and store of electrical energy

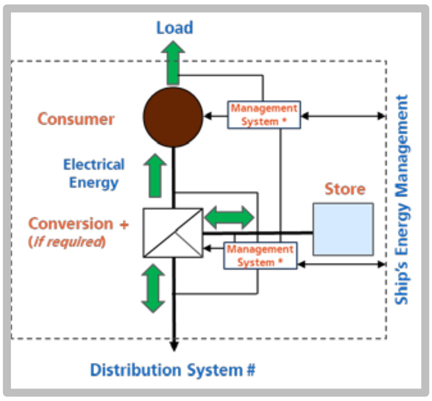


Figure 2.24.6 Combined store of electrical energy and consumer of electrical power

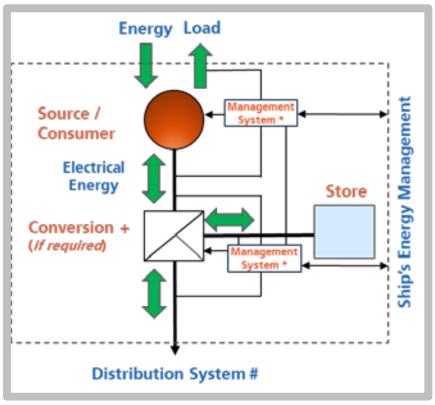


Figure 2.24.7 Combined store of electrical energy and source and consumer of electrical power

24.3.8 Distribution system: The distribution system provides the interconnection between, protection of and isolation of:

- sources (*see Pt 6, Ch 2, 24.3 Definitions 24.3.3* to *Pt 6, Ch 2, 24.3 Definitions 24.3.4*),
- stores (*see Pt 6, Ch 2, 24.3 Definitions 24.3.5*),
- consumers (*see Pt 6, Ch 2, 24.3 Definitions 24.3.6*) and
- combinations thereof (*see Pt 6, Ch 2, 24.3 Definitions 24.3.7*).

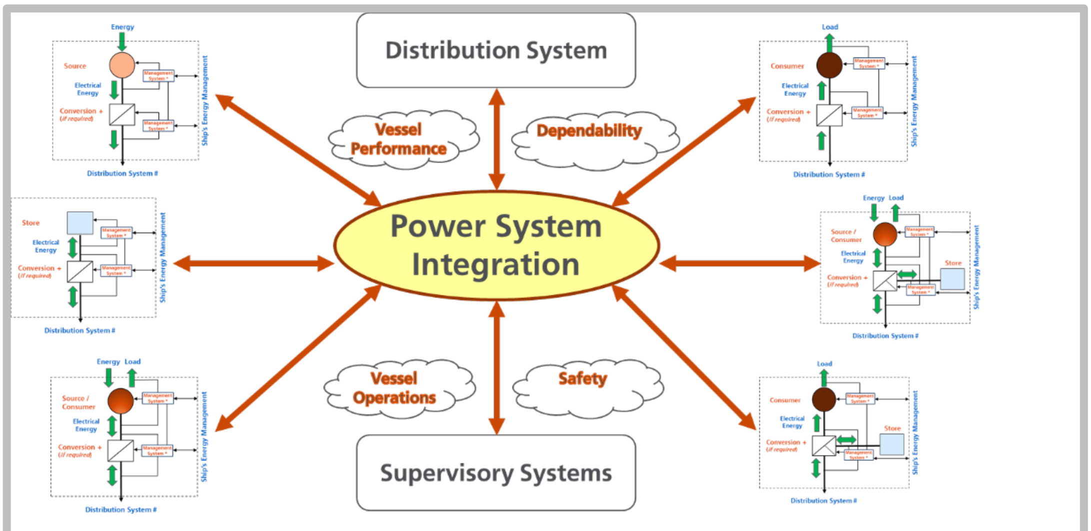
It includes management systems (e.g. power management) and any required dedicated conversion as described in *Pt 6, Ch 2, 24.3 Definitions 24.3.3*. There are no constraints on its type (e.g. a.c. or d.c.), magnitude (e.g. voltage and/or frequency), nature (e.g. fixed or variable), architecture (e.g. tree, radial, zonal), physical form or on the number of variants within a ship.

24.3.9 Energy management: Energy management functionality provides the overall control, monitoring, protection and safety functions that are necessary to deliver dependable electrical power from the hybrid electrical power system in all operating modes and under both normal and reasonably foreseeable abnormal conditions. It comprises supervisory functions that integrate the management systems of the components (sources, stores, consumers, distribution systems) from which the hybrid system is constructed and may be implemented as a stand-alone system or as distributed functionality across a number of systems.

Energy management is focused on energy flow and is typically model based, predictive in nature, inclusive of optimisation functionality and employing the principles of health and condition monitoring at system level (e.g. as described in *ShipRight Procedure for the Approval of Digital Health Management Systems*).

Energy management functionality is considered additional to the functionality of a conventional power management system as described in IEC 60092-504, *Electrical installations in ships, Part 504: Automation, control and instrumentation,* Section 9.4.

24.3.10 Power system integration: Power system integration comprises those system level activities that are required to be undertaken to design and develop, build and then operate and maintain safely through life a dependable ship's hybrid electrical power system including its constituent components (shown pictorially in *Figure 2.24.8 Role of system integration activities*). At each phase of a project power system integration is managed by a single designated party and is carried out in accordance with a defined procedure identifying the roles, responsibilities and requirements for all parties involved.



* "Supervisory Systems" may include Integrated Automation Systems (IAS), Power / Energy Management Systems (PMS / EMS), Dynamic Positioning (DP) Control Systems, Health / Condition Monitoring Systems, ….. etc.

Figure 2.24.8 Role of system integration activities

24.3.11 Dependability: Dependability is as defined in IEC 60050(191), *Quality vocabulary – Part 3: Availability, reliability and maintainability terms – Section 3.2: Glossary of international terms*. It is the collective term used to describe the availability performance and its influencing factors: reliability performance, maintainability performance and maintenance support performance as agreed with LR.

24.4 Hybrid electrical power system performance - System functional requirements

24.4.1 To provide sufficient electrical power of appropriate dependability to supply the required essential services, habitability requirements and those services required to maintain the ship in a normal sea-going and operational state during defined operational conditions without recourse to the emergency electrical supply.

24.4.2 Damage and injury: To provide electrical systems and equipment with suitable protection under fault conditions to prevent the following:

(a) injury to onboard personnel;
(b) damage to the equipment itself; and
(c) damage to equipment connected to it.

24.4.3 On ships with electric propulsion, to provide sufficient electrical power necessary for an effective and agreed level of propulsion power during all normal and reasonably foreseeable abnormal operational conditions.

24.5 Hybrid electrical power system performance - System performance targets

24.5.1 For **Hybrid Power** notation the performance of the system is to be such that in the event of a single failure operation of the system may be interrupted but is to be recoverable to a defined state bounded by time and magnitude.

24.5.2 For **Hybrid Power (+)** notation the performance of the system is to be such that in the event of a single failure operation of the system is to be uninterrupted with any degradation of performance agreed between the designers and Owners.

24.5.3 The hybrid electrical power system performance targets in all modes of operation are to be defined and agreed between the designers and Owners.

24.5.4 The electrical system design maximum and minimum operating voltage and input frequency together with acceptable limits of excursions are to be specified by the system designer and are to be in compliance with the requirements of the rules.

24.5.5 Specific consideration is to be given to time-based performance targets for systems in which stored electrical energy supplies any part of the ship's main power demand.

24.5.6 Methods of verification of actual performance against targets are to be defined and are to cover all phases of the lifecycle.

24.6 Hybrid electrical power system performance - Dependability principles

24.6.1 The hybrid electrical power system dependability principles are to be defined and agreed between the designers and Owners consistent with the requirements for **Hybrid Power** or **Hybrid Power (+)** notation.

24.6.2 The principles are to cover defined operating modes, all normal and reasonably foreseeable abnormal operating and fault conditions and are to specifically consider the fault ride-through capability of the system.

24.6.3 The principles are to cover failures in active components of any of the sources, stores, consumers, distribution system and energy management forming the hybrid electrical power system. Such components may include, but are not restricted to, the following:

(a) prime movers (e.g. auxiliary engines);
(b) generators and their excitation equipment;
(c) gearing;
(d) pumps;
(e) fans;
(f) switchgear and controlgear, including their assemblies;
(g) thrusters; and
(h) valves (where power actuated).

24.6.4 Consideration is to be given to other enabling systems not part of the hybrid electrical power system whose failure or degradation could affect correct functioning of the hybrid electrical power system (e.g. lubrication, cooling and ventilation systems).

24.6.5 The continuity of supply to essential and emergency safety systems is to be maintained, in accordance with *Pt 6, Ch 2, 2 Main source of electrical power*.

24.6.6 Arrangements are to ensure that the supply of essential services is not disrupted by the unavailability of the largest source of electrical power and are to be in accordance with a clearly described, documented and agreed redundancy design intent.

24.6.7 The size and rating of electrical energy stores is to be appropriate for the specified lifetime when subjected to in-service cyclic loading. Calculations supporting this assessment are to be provided to LR.

24.6.8 For **Hybrid Power (+)** a hybrid electrical power system dependability assessment is to be undertaken and submitted to LR. The objectives of the assessment are to:
(a) demonstrate the dependability of the system during all normal and reasonably foreseeable abnormal conditions; and
(b) demonstrate that an appropriate level of dependability is achieved that is commensurate with that agreed between the designers and Owners.

The assessment shall be undertaken to a recognised standard that is acceptable to LR (e.g. IEC 60300-3-1*, Dependability management Part 3-1: Application guide – Analysis techniques for dependability – Guide on methodology*).

24.7 Hybrid electrical power system performance - Main source of electrical power

24.7.1 The main source of electrical power is to comply with the requirements of *Pt 6, Ch 2, 2 Main source of electrical power*.

24.7.2 Any type of source of electrical power as detailed in these hybrid electrical power system Rules may, subject to the approval of LR, be considered as having equivalent function to that of a generating set as described in, but not limited to, *Pt 6, Ch 2, 2 Main source of electrical power*.

24.7.3 Sources of electrical power not forming part of the ship's main source of electrical power may be used as an additional source of electrical power to supply electrical services required for normal operational and habitable conditions provided that:
(a) The quality of power supplies meets the requirements of *Pt 6, Ch 2, 24*.17 *Transversal requirements 24.17.3*; and
(b) Automatic arrangements are provided to start and connect within a period not exceeding 45 seconds one of the sources forming the main source of electrical power in the event of a single failure or the quality of power supplies exceeding limits.

24.8 Hybrid electrical power system performance - Emergency source of electrical power

24.8.1 The emergency source of electrical power is to comply with the requirements of *Pt 6, Ch 2, 3 Emergency source of electrical power*.

24.8.2 For ships with a specified service notation as defined in *Pt 1, Ch 2, 2.3 Class notation (hull)*, where it is proposed that a dedicated emergency source of electrical power and its associated transitional source of power will not be provided, the main source of electrical power and associated equipment is to meet the following requirements:
(a) Sources providing the main source of electrical power are to be:
    i. separated and located in two or more compartments that are not contiguous with each other;
    ii. self-contained and arranged to be independent such that each system can operate without recourse to the other main source(s) including power distribution and any associated auxiliary and ancillary converting equipment and control systems;
    iii. arranged such that a fire, flood or casualty in any one of the compartments will not affect the electrical power distribution from the other(s), or to the services required by *Pt 6, Ch 2, 3 Emergency source of electrical power*;
    iv. capable of being started automatically on loss of the power supplied by the other main source(s) of electrical power and supplying the essential services as quickly as is safe and practicable subject to a maximum of 45 seconds, or provided with a transitional source of emergency electrical power;
    v. arranged to allow for maintenance at sea of any one source without affecting the ability to comply with these requirements; and
    vi. provided with starting arrangements compliant with the requirements of *Pt 5, Ch 2, 9.5 Starting of the emergency source of power.*
(b) Where these Rules specify that a service is required to be connected to both the main and emergency source of electrical power or is to be connected to the emergency switchboard, then these services are to be served by at least two individual circuits from the separated main sources of electrical power with arrangements to transfer between the two sources. The supplies are to be separated in their switchboard and throughout their length as widely as is practicable without the use of common feeders, protective devices, control circuits or controlgear assemblies so that any single fault will not cause the loss of both supplies.

(c) Provision is to be made for periodic testing to demonstrate services required by *Pt 6, Ch 2, 3 Emergency source of electrical power* can be supplied automatically following the loss of one main source of electrical power.

(d) To demonstrate compliance with these requirements a risk assessment of the electrical, mechanical, piping arrangements, cooling arrangements and any other sub-systems whose failure or degradation could have an impact on the performance of the system is to be carried out demonstrating that a single point failure such as a fire or flooding within a space would not render the systems incapable of supplying those services required in an emergency or other reasonably foreseeable abnormal event. The assessment is to be undertaken to a recognised standard that is acceptable to LR (e.g. ISO 31010*, Risk management – Risk assessment techniques*) and in accordance with *ShipRight Procedure Assessment of Risk Based Designs* and associated annexes.

24.9 Hybrid electrical power system performance - External source of electrical power

24.9.1 Ships utilising an external source of power are to comply with the requirements of *Pt 6, Ch 2, 4 External source of electrical power*.

24.9.2 Arrangements for d.c. external sources are to comply with a recognised standard that is acceptable to LR.

24.9.3 Onshore power supplies and their connection are to comply with *Pt 7, Ch 13 On-shore Power Supplies*.

24.9.4 Ships using an external source of power to charge onboard stores of electrical energy will be specifically considered by LR. Details of the arrangements and their interfaces to ship systems are to be submitted.

24.10 Hybrid electrical power system performance - Electrical power supply to ship propulsion and ship positioning systems

24.10.1 Ships with electric propulsion are to comply with the relevant power requirements of *Pt 6, Ch 2, 16.3 Power requirements*.

24.10.2 Ships with electrically driven azimuthing thrusters are to comply with the relevant power requirements of *Pt 5, Ch 20, 5.2 Generating arrangements 5.2.2*.

24.10.3 Ships with dynamic positioning systems are to comply with the relevant power requirements of *Pt 7, Ch 4 Dynamic Positioning Systems*.

24.10.4 Passenger ships are to comply with the relevant power requirements of *Pt 5, Ch 23 Additional Requirements for Passenger Ships* and the *ShipRight Procedure for Assigning the SRtP Descriptive Note*.

24.10.5 Ships with optional notations for propulsion and steering redundancy are to comply with the relevant power requirements of *Pt 5, Ch 22, 3.3 Electrical power supply*.

24.10.6 Ships with the optional notation for integrated propulsion systems are to comply with the relevant power requirements of *Pt 5, Ch 18, 2 Machinery arrangements*.

24.11 Hybrid electrical power system components - Source of electrical power

24.11.1 The main source of electrical power is to comply with the requirements of *Pt 6, Ch 2, 2 Main source of electrical power*.

24.11.2 The emergency source of electrical power is to comply with the requirements of *Pt 6, Ch 2, 3 Emergency source of electrical power*.

24.11.3 External sources of electrical power are to comply with the requirements of *Pt 6, Ch 2, 4 External source of electrical power*.

24.11.4 Additional sources of electrical power as defined in *Pt 6, Ch 2, 24.3 Definitions 24.3.4* are to comply with the requirements of this Chapter.

24.11.5 Rotating electrical generators within sources of electrical power are to comply with the requirements of *Pt 6, Ch 2, 9 Rotating machines*.

24.11.6 Converters within power sources are to comply with *Pt 6, Ch 2, 10.2 Semiconductor converters* and the following requirements:

(a) Converters are to be selected to withstand the voltage ripple levels present on the distribution system. For every system, the following voltage parameters are to be defined:
  i. maximum non-repetitive peak;
  ii. maximum repetitive peak; and
  iii. maximum repetitive peak-to-peak.

(b) Where pulse width modulation converters are to be used, the voltage rate of rise times are to be determined, the results recorded and submitted to LR. Rotating machinery, surge protective devices, cable insulation and motor windings are to be designed accordingly.

(c) Converters may be of conversion type a.c./a.c., d.c./a.c., a.c./d.c., d.c./d.c., and of the controlled (e.g. active front end (AFE)) or non-controlled type (e.g. diode supply unit (DSU)).

(d) Converters are to be provided with visual status indication at their associated control stations to include, but not be limited to:
  i. Power available at the input;
  ii. Power at output;

    iii. Temperature; and
    iv. Overload.

  If certain indicators and alerts are not applicable, sufficient evidence to support the claim is to be submitted for consideration by LR. Additional indicators, alerts and shutdowns may be necessary as determined through the system Failure Modes and Effects Analysis (FMEA) required by *Pt 6, Ch 2, 24.27 Power system development and integration - System Failure Modes and Effects Analysis (FMEA)*.

(e) Converters supplying electrical power to the distribution system and consumers are to be capable of delivering the required currents for the time required to enable current-time discrimination of protective devices to operate. The electrical output of the converter is to be automatically restored following fault clearance.
(f) Converter software is to satisfy the requirements of *Pt 6, Ch 1, 2 Essential features for control, alarm, monitoring and safety systems.*
(g) Converters are to be capable of handling voltage and current spikes from the distribution system under all normal and reasonably foreseeable abnormal conditions without sustaining any damage or tripping.
(h) Converters supplying essential services are to automatically restart and connect to the distribution system after a blackout as specified in *Pt 6, Ch 2, 2.2 Number and rating of generators and converting equipment*.
(i) Where converters are equipped with internal capacitors which can contribute significantly to the short-circuit level of the system, the contribution is to be included in the design of the protection and distribution system.
(j) The risk of converter component damage due to inrush currents is to be minimised by appropriate management of these currents during transient events and after short circuit.
(k) Where capacitors are connected to a converter output, the output is to be charged by the converter or by external chargers to a level which will minimise the risk of damage to the capacitors before connecting them to the distribution system.
(l) Converters arranged to operate in parallel are to be capable of stable load sharing up to maximum continuous load and inclusive of any temporary overloads within their design rating.
(m) Where converters are arranged to provide protection against electrical faults a disconnector or switch disconnector is to be provided to enable safe isolation of the converter from its incoming supplies.
(n) Converters are to be protected from permanent physical damage as a result of short circuits or overload currents on their input and output terminals.
(o) Converters are to have a ride-through capability to manage system transients including the effects of fault clearance in the distribution system that is consistent with the dependability requirements of the system.
(p) Converters are to be provided with appropriate filters to ensure the required quality of power supply at both their input and output. In the event of filter circuit failure, continued safe operation of the hybrid electrical power system is to be possible by following specified procedures as described in operation procedures. These procedures are to include any operational limitations, and they are to be kept on board, maintained in accordance with *Pt 6, Ch 2, 24.18 Power system development and integration - General 24.18.3* and made available to the Surveyor on request.

24.12 Hybrid electrical power system components - Store of electrical energy

24.12.1 Functional requirements: To provide sufficient stored electrical energy as a component of the main source of power to supply services during normal and reasonably foreseeable abnormal and emergency conditions.

24.12.2 Batteries of the vented and valve-regulated sealed type and lithium batteries are to comply with *Pt 6, Ch 2, 12 Batteries*.

24.12.3 Power converters within stores of electrical energy as illustrated in *Pt 6, Ch 2, 24.3 Definitions 24.3.5* are to comply with the relevant requirements of *Pt 6, Ch 2, 24.11 System components - Power source 24.11.6*.

24.12.4 For consideration as a component of the main source of power on a ship with a specified service notation as defined in *Pt 1, Ch 2, 2.3 Class notations (hull)* and subject to approval of the National Administration a store of electrical energy is to:
(a) Comply with *Pt 6, Ch 2, 24.7 Hybrid electrical power system performance - Main source of electrical power*;
(b) Have a minimum capacity at any stage of its lifecycle sufficient for its contribution to the main source of power that is necessary to achieve the specified service requirements;
(c) Be provided via energy management functionality with remote indication of state of charge (available capacity in a store expressed as a percentage of rated capacity) and state of health (general condition of a store expressed as a percentage of its ability to deliver the specified performance compared with that of a new store);
(d) Have a primary purpose of supplying the ship’s main power demand. Details of any secondary purpose including but not limited to optimising performance (e.g. load smoothing, peak shaving), improving stability (e.g. dynamic response) or providing transitional power are to be provided to LR; and
(e) Be capable of being restored from a dead-ship condition with no dependence on other systems or electrical supplies. Details of alternative arrangements may be submitted for consideration by LR.

24.12.5 For consideration as an additional source of power a store of electrical energy is to:
(a) Comply with *Pt 6, Ch 2, 24.7 Hybrid electrical power system performance - Main source of electrical power 24.7.3*;
(b) Be provided via energy management functionality with remote indication of state of charge (available capacity in a store expressed as a percentage of rated capacity) and state of health (general condition of a store expressed as a percentage of its ability to deliver the specified performance compared with that of a new store); and
(c) Have a primary purpose of supplying the ship’s main power demand. Details of any secondary purpose including but not limited to optimising performance (e.g. load smoothing, peak shaving), improving stability (e.g. dynamic response) or providing transitional power are to be provided to LR.

24.12.6 For application as an emergency source of power a store of electrical energy is to comply with *Pt 6, Ch 2, 24.8 Hybrid electrical power system performance - Emergency source of electrical power.*

24.12.7 Electrical energy storage devices connected to and charged by the distribution system are to be protected against the defined effects of electrical faults in the system.

24.12.8 Energy stores connected to and charged by the distribution system are to be so located and provided with arrangements allowing for the safe isolation of their terminals and the reduction of voltages to a safe level during maintenance or provided with alternative arrangements providing an equivalent level of safety which will be subject to special consideration.

24.12.9 Energy stores are to be connected to the distribution system by protection devices which include but are not limited to overcurrent and short circuit protection. The protective devices used are to be selective, ensuring faults are not transmitted further, independent of the direction of current flow.

24.13 Hybrid electrical power system components - Consumer of electrical power

24.13.1 Functional requirements: To convert electrical power supplied from the hybrid power generation and distribution system into useful work.

24.13.2 Rotating machines within consumers of electrical power are to comply with the requirements of *Pt 6, Ch 2, 9 Rotating machines*.

24.13.3 Converters within consumers of electrical power are to comply with the relevant requirements of *Pt 6, Ch 2, 24.11 System components - Power source 24.11.6*.

24.13.4 Where a converter is arranged to step down voltage to provide a lower voltage supply to consumers than that of the power system, then arrangements are to be provided to ensure the lower voltage distribution consumers are not subjected to voltage variations, including fast transients, outside their safe operating regions.

24.13.5 Consumers employing loads characterised by constant power characteristics connected to the distribution system through a converter are to be evaluated with respect to ensuring the stability of the power system as part of the power system analysis detailed in *Pt 6, Ch 2, 24.24 Power system development and integration - Power system analysis*.

24.14 Hybrid electrical power system components - Combined sources of electrical power, stores of electrical energy and consumers of electrical power

24.14.1 Functional requirements: To provide the combined functional requirements of each of the elements (sources, stores, consumers) from which the combination is constructed.

24.14.2 Where a single functional or physical assembly contains a combination of source, store or consume functions, then it is to comply with the requirements of each applicable function as detailed in *Pt 6, Ch 2, 24.11 System components - Power source* to *Pt 6, Ch 2, 24.13 System components – Consumer of electrical power*.

24.15 Hybrid electrical power system components - Distribution system

24.15.1 Functional requirements:
(a) To provide a dependable interconnection between sources, stores and consumers of electrical power; and
(b) To distribute electrical power safely to consumers.

24.15.2 Arrangements for isolation and switching are to be provided which are to enable safe isolation of faults and for maintenance.

24.15.3 Distribution systems supplying consumers through converters are to provide galvanic isolation and ground separation.

24.15.4 In addition to the requirements of *Pt 6, Ch 2, 5.3 Isolation and switching*, systems are to comply with the requirements of *Pt 6, Ch 2, 24.15 Hybrid electrical power system components – Distribution system 24.15.5 to Pt 6, Ch 2, 24.15 Hybrid electrical power system components – Distribution system 24.15.13*.

24.15.5 Where consumers are supplied via converters which are connected to both sides of a distribution system that is capable of being split, arrangements are to be provided to eliminate the risk of current being supplied back to the distribution system for example through flyback diodes.

24.15.6 Converters connecting sources, stores and consumers connected to the distribution system are to facilitate the connection and removal of sources, stores and consumers in a stable manner with the electrical power system in operation.

24.15.7 Converters are to be designed to prevent damage to the converter when switching under load.

24.15.8 Where essential services are required by *Pt 5 Main and Auxiliary Machinery* to be duplicated, these are to be served by individual circuits, separated in their switchboard or section board and throughout their length as widely as is practicable without the use of common feeders, protective devices, control circuits or controlgear assemblies, so that any single fault will not cause the loss of both services.

24.15.9 The distribution system is to be split into at least two independent systems each capable of independent operation or is to be separated by protection devices that are selective, ensuring faults are not transmitted further, and operate independent of the direction of current flow.

24.15.10 The distribution system is to be protected against electrical faults including short circuit, overload, earth fault, differential current, under/over voltage, under/over frequency, power quality, current and voltage imbalance and arc fault in compliance with the relevant requirements of *Pt 6, Ch 2, 6 System design – Protection* and *Pt 6, Ch 2, 24.15 Hybrid electrical power system* *components – Distribution system 24.15.11* to *Pt 6, Ch 2, 24.15 Hybrid electrical power system components – Distribution system 24.15.14*.

24.15.11 Active components may be used for the limitation of fault currents subject to verification in a real environment of the performance of the component under all normal and reasonably foreseeable abnormal operating and fault conditions and subject to establishment of effective surveillance and periodic test procedures during operation and maintenance in the ship's operating manuals to verify the component is capable of performing its intended function. An isolation device is to be provided within the component and this is to be tripped automatically in the event of the component operating. A risk assessment of the component is to be undertaken to a recognised standard that is acceptable to LR (e.g. ISO 31010*, Risk management – Risk assessment techniques*) and in accordance with *ShipRight Procedure Assessment of Risk Based Designs* and associated annexes.

24.15.12 Where energy management functionality provides protection against incorrect or unexpected energy flows between the sources, stores and consumers forming part of the hybrid electrical power system the sensors used for this purpose in the distribution system are to be independent of those used for control, monitoring and safety systems.

24.15.13 Where a bi-directional flow of power may occur, the distribution system is to withstand the power variations being introduced. The level of bi-directional flow allowed is to be specified by the system designer.

24.15.14 For **Hybrid Power (+)** notation facilities are to be provided for automatic detection of the location of insulation breakdown with respect to earth of equipment and distribution systems to a level determined by the integrator consistent with the system's dependability targets and agreed with the designers and Owners.

24.15.15 For either notation, switchgear and controlgear are to comply with the relevant requirements of *Pt 6, Ch 2, 7 Switchgear and controlgear assemblies*.

24.15.16 Power converters within distribution systems are to comply with the relevant requirements of *Pt 6, Ch 2, 24.11 Hybrid electrical power system components - Power source 24.11.6*.

24.15.17 Where fuses are implemented to limit the fault current in the converter, the activation of the protection is not to influence redundant consumers or cause loss of other single consumers as required by *Pt 6, Ch 2, 5.2 Essential services*.

24.15.18 Fuses used to protect distribution converters are to be of the bolted type. Where alternative arrangements are proposed, it is to be demonstrated that protection system's selectivity is not adversely affected as a result of an increased connection resistance.

24.15.19 For each section of a d.c. bus there is to be at least one voltmeter per section. An ammeter is to be provided for each converter supplying a d.c. bus. Similar arrangements are to be provided for screen-based displays.

24.15.20 The meters required by *Pt 6, Ch 2, 24.15 Hybrid electrical power system components – System design 24.15.19* are to be located and arranged such that they may be viewed at a single operating position. In addition, meters may be required at additional locations to mitigate hazards identified by the risk assessment required by *Pt 6, Ch 2, 24.27 Power system development and integration - System Failure Modes and Effects Analysis (FMEA)*.

24.15.21 Power quality assessments are to consider the detection and impacts of circulating currents such as may exist through capacitive coupling in semiconductor converters.

24.15.22 Constant current distribution systems will be subject to special consideration and are not covered by these Rules.

24.15.23 For **Hybrid Power (+)** notation warnings of degrading power quality are to be provided and in the event of power quality exceeding prescribed limits automatic isolation and reconfiguration of the power system is to occur as agreed between the designers and owners.

24.16 Hybrid electrical power system components - Energy management

24.16.1 Functional requirements:
(a) To ensure that sufficient energy is available to satisfy the main power demand under all foreseeable operational conditions.
(b) To inform Operators as soon as reasonably practicable of deviations from normal operation of the hybrid electrical power system under all normal and reasonably foreseeable abnormal operational conditions.
(c) To initiate immediate corrective action on detection of component faults in the hybrid electrical power system that present a danger, reducing the risk to a level that is acceptable to LR.
(d) To provide functionality beyond the scope of conventional power management that is necessary for the control, monitoring, protection and dependability of the hybrid electrical power system.

24.16.2 Programmable electronic systems used to provide energy management functionality, or to provide safety functions, are to have arrangements which satisfy the applicable requirements of *Pt 6, Ch 1, 2 Essential features for control, alarm, monitoring and safety systems*.

24.16.3 Proposed modifications to software, including parameter changes, and during acceptance testing and trials are to be in accordance with *Pt 6, Ch 1, 1.5 Alterations and additions* as applicable.
24.16.4 Loss of energy management functionality is not to compromise the supply of main power, the safety of the ship, the hybrid electrical power system, or its components.

24.16.5 Energy management functionality is to include, but not be limited to, the following:

(a) Control (of the complete system and of each of its sub-systems):
  i. hybrid electrical power system operating mode selection and transition;
  ii. connection and disconnection of sources, stores and consumers to the distribution system in response to operating conditions and prevailing loads;
  iii. connection and disconnection of distribution system sections;
  iv. load allocation to and sharing between sources;
  v. load restriction of consumers;
  vi. energy flow management;
  vii. distribution system a.c. voltage and frequency and d.c. voltage; and
  viii. control functions required by sources, stores, consumers or distribution system that are necessary for their operation under all reasonably foreseeable normal, abnormal and fault conditions.

(b) Alarm and monitoring:
  i. mode transition status;
  ii. connection status of sources, stores, consumers and distribution system sections;
  iii. energy flows within the hybrid electrical power system and between its constituent parts;
  iv. power quality as detailed in *Pt 6, Ch 2, 24.17 Transversal requirements 24.17.3*; and
  v. for stores, state of charge and state of health as defined in *Pt 6, Ch 2, 24.12 System components - Store of electrical energy 24.12.4* and *Pt 6, Ch 2, 24.12 System components - Store of electrical energy 24.12.5*.

(c) Protection and safety:
  i. blackout prevention;
  ii. blackout recovery;
  iii. detection of abnormal or unexpected energy flow as described in *Pt 6, Ch 2, 24.15 System components - Distribution system 24.15.12*; and
  iv. safety functions required by sources, stores, consumers or distribution system that are necessary for their safe operation.

24.16.6 Overall ship-wide energy management functionality is to be integrated and coordinated with the functionality of the local management systems as described in *Pt 6, Ch 2, 24.3 Definitions* for each of the components (sources, stores, consumers, combinations, distribution system) of the hybrid electrical power system and is to ensure safe operation of the ship under all normal and reasonably foreseeable abnormal operating and fault conditions.

24.16.7 Additional energy management functionality for **Hybrid Power (+)** notation is to consider, but not be limited to, the following. The level of functionality supplied is to be consistent with the enhanced performance and dependability required by the system.

(a) Control (of the complete system and of each divisible element):
  i. automatic configuration of the power system based on predicted energy flow;
  ii. automatic system isolation and reconfiguration such that, in the event of a single failure in electrical power sources, stores, distribution system or associated control systems, the impact on the operational performance of the ship is as agreed with LR and there is no impact on the ship's ability to complete its mission;
  iii. system performance optimisation, independent of primary control functions covering emissions, efficiency, availability, reliability or operating cost; and
  iv. control of stores with load smoothing, peak shaving, dynamic response or other optimisation capability.

(b) Alarm and monitoring:
  i. degradation of power quality;
  ii. remaining time for continued operation of the power system at current operating conditions and levels of power consumption. This may take the form of a real-time performance capability plot;
  iii. system performance covering energy consumption, emissions, efficiency, availability, reliability or operating cost; and
  iv. health and condition of hybrid electrical power system components including the effects of ageing on electrical energy storage devices.

(c) Protection and safety:
  i. automatic isolation and reconfiguration of the power system on detection of abnormal energy flow;
  ii. consequence analysis determining the remaining time for continued operation of the power system under stated operating and load conditions following the most significant single failure. This may take the form of an onboard off-line simulation derived from, or an integral element of, the simulation described in *Pt 6, Ch 2, 24.23 Power system development and integration – Energy flows 24.23.3*; and
  iii. automatic detection of faults detailed in the system level FMEA with display of mitigating actions.

24.16.8 A description of functionality including also any functions not described in *Pt 6, Ch 2, 24.16 Hybrid electrical power system components – Energy management 24.16.5* and *Pt 6, Ch 2, 24.16 Hybrid electrical power system components – Energy management 24.16.7* is to be submitted.

24.17 Transversal requirements

24.17.1 All electrical equipment is to prevent injury to personnel or damage to other equipment and is to be suitably protected against damage to itself under normal, reasonably foreseeable abnormal and fault conditions.

24.17.2 The supply of electrical power sufficient for the correct operation of electrical services for essential equipment and habitable conditions is to be maintained:

(a) during all normal and reasonably foreseeable abnormal operating and fault conditions;
(b) irrespective of the direction of the propulsion shaft rotation; and
(c) without any requirement to revert to emergency supplies.

24.17.3 Hybrid electrical power systems are to provide a power quality as required by;

- *Pt 5, Ch 2, 7.3 Auxiliary engine governors*,
- *Pt 6, Ch 2, 1.8 Quality of power supplies*,
- *Pt 6, Ch 2, 2.4 Prime mover governors* and
- *Pt 6, Ch 2, 9.4 Generator control*

during all normal and reasonably foreseeable abnormal operating and fault conditions.

24.17.4 A.c. and d.c. systems are during all normal and reasonably foreseeable abnormal operating and fault conditions to provide a quality of power as required by a recognised National or International Standard specified by the power system integrator that is acceptable to LR.

24.17.5 All components of, or connected to, the distribution system are to be designed and validated for operation across the full range of power quality conditions detailed in *Pt 6, Ch 2, 24.17 Transversal requirements 24.17.2* to *Pt 6, Ch 2, 24.17 Transversal requirements 24.17.4*.

24.17.6 The key parameters of power quality as determined by the system integrator with agreement of the owner and as applicable to the type of electrical power system are to be monitored and recorded for each individually operable section of the distribution system. An alarm is to be raised at a monitored operating station in the event of power quality exceeding limits determined by the system integrator in compliance with the power quality requirements of the rules. A description of the arrangements provided is to be submitted.

24.17.7 For either notation, all electrical equipment is to comply with the requirements of *Pt 6, Ch 2 Electrical Engineering* including:
(a) general requirements - *Pt 6, Ch 2, 1 General requirements* including fire, electric shock, ignition, radiation and environment;
(b) creepage and clearance - *Pt 6, Ch 2, 7.5 Creepage and clearance distances*;
(c) arc - *Pt 6, Ch 2, 8 Protection from electric arc hazards within electrical equipment*; and
(d) explosive atmospheres - *Pt 6, Ch 2, 14 Electrical equipment for use in explosive gas atmospheres or in the presence of combustible dusts*.

24.17.8 The choice of materials and components of construction, as well as the design, location and ship installation, are to be made according to the environmental, maintenance and operating conditions in order to maintain the continued function of the equipment during all normal and reasonably foreseeable abnormal conditions and to reduce the risk of:
(a) injury to onboard personnel;
(b) damage to the equipment the system is contained within or adjacent equipment and systems;
(c) damage to adjacent equipment and systems; and
(d) damage to the ship.

24.17.9 Where applicable, equipment and components are to be selected from the list of LR type approved products satisfying the requirements of *Pt 6, Ch 1, 1.4 Control, alarm and safety equipment* and *Pt 6, Ch 1, 2.13 Programmable electronic systems - Additional requirements for essential services and safety critical systems*.

24.17.10 Electrical equipment is to be used within its designed operating parameters, such as current, voltage, power, charging rate, energy storage, etc. to prevent:
(e) a hazard occurring; and
(f) the equipment affecting safety functions.

24.17.11 All electrical equipment supplied from the main and emergency sources of electrical power and electrical equipment for essential and emergency services is to be selected to operate satisfactorily under the variations of voltage and ripple frequencies which may be present in the system.

24.17.12 Cables and busbars are to be selected and installed in accordance with *Pt 6, Ch 2, 11 Electric cables, optical fibre cables and busbar trunking systems (busways)*.

24.17.13 Transformers within the hybrid electrical power system are to comply with the relevant requirements of *Pt 6, Ch 2, 10.1 Transformers*.

24.17.14 Interlocks or an alternative acceptable to LR are to be provided which will prevent access to capacitors until their voltage level has reduced to below the safe extra low voltage level (50 V); this is to ensure safety of personnel during maintenance.

24.18 Power system development and integration - General

24.18.1 The activities specified in *Pt 6, Ch 2, 24.19 Power system development and integration - System operational concept* to *Pt 6, Ch 2, 24.31 Verification requirements* are to be undertaken to deliver and maintain a safe and dependable hybrid electrical power system throughout its development, detail design, construction, integration, verification and acceptance. Procedures are to be made available detailing how these activities will be maintained during ship operation, maintenance and disposal.

24.18.2 The activities should be based on the principles of the following five levels with measures adopted at each level being, as far as practicable, independent of each other:
(a) prevention of abnormal operation and failures though design and high quality in construction, operating rules and normal operating procedures;
(b) control of abnormal operation and detection of failures through control, limiting and protection systems, monitoring/surveillance features and abnormal/emergency operating procedures;

(c) control of hazards within the system design to protect against escalation to an incident or accident through engineered safety features and emergency operating procedures;
(d) in support of and coordinated by the Owner and ship designer, control of severe ship or infrastructure conditions that may exceed the system design intent including prevention of hazard progression and mitigation of hazardous consequences through complementary procedures and hazard management; and
(e) in support of and coordinated by the Owner and ship designer, mitigation of accident consequences through emergency response.

The system designer is to ensure adoption of principles (a) to (c) during the development and integration of the hybrid electrical power system providing evidence to LR through the documentation that is submitted for design review as detailed in *Pt 6, Ch 2, 1.2 Documentation required for design review 1.2.17*.

24.18.3 At each phase of a project integration activities are to be managed by a suitably competent single designated party and are to be carried out in accordance with a defined procedure identifying the roles, responsibilities and requirements of all parties involved.

24.18.4 Where the designated party changes during a project, then there is to be a full and auditable transfer of necessary integration information between the parties.

24.18.5 Systems engineering processes are to comply with *ISO 15288 Systems and Software Engineering – System Life Cycle Processes* or an acceptable equivalent National or International Standard.

24.19 Power system development and integration - System operational concept

24.19.1 The system operational concept is to be defined including a description of how the control, alarm and safety systems for the hybrid electrical power system provide effective means for operation and control during all defined ship operational conditions.

24.19.2 The system operational concept is to detail the capability, functionality and modes of operation under defined operating and emergency conditions and is to be agreed between the designers and Owners.

24.19.3 The system operational concept is to be submitted for design review.

24.20 Power system development and integration - Operating modes

24.20.1 Operating modes for the hybrid electrical power system are to be defined and agreed between the designers and Owners.

24.20.2 Modes are to cover all normal and reasonably foreseeable abnormal operating and fault conditions.

24.20.3 Modes are to be compatible with the ship’s overall operating modes.

24.20.4 The sequence of transition between operating modes is to be defined for all reasonably foreseeable normal and abnormal operating and fault conditions.

24.20.5 A technical description is to be produced specifying for each of the ship’s possible operating modes:
(a) the type of each electrical power source used to supply the distribution system, such as a.c. generators, d.c. generators, converter, batteries, fuel cells and photovoltaics;
(b) the operating mode of each electrical power source such as constant voltage, constant current or variable voltage;
(c) the configuration of the electrical distribution system, including the earthing and protection strategies to be used; and
(d) the worst-case failure design intent.

24.21 Power system development and integration - Consumer categorisation

24.21.1 Consumers supplied with electrical power from the hybrid electrical power system are to be categorised according to their function and the services that they provide in accordance with the requirements of *Pt 6, Ch 2, 1.6 Definitions*.

24.22 Power system development and integration - System components

24.22.1 The specifications for all components of the hybrid electrical power system (sources, stores, consumers, distribution system, energy management) are to be validated by the system designer for completeness and correctness in respect of the component’s integration into the overall power system. Validated specifications are to be submitted to LR.

24.22.2 Details of the following are to be specified:
(a) operating modes and the transition between them;
(b) control and monitoring functions;
(c) mechanical components which might affect the hybrid notation (e.g. cooling units with piping arrangements, pumps, valves, etc.);
(d) safety functions;
(e) failure modes;
(f) isolation;
(g) initial and through-life verification of conformance; and
(h) human element.

24.23 Power system development and integration - Energy flows

24.23.1 Energy flows within the hybrid electrical power system are to be determined for all operating modes and all normal and reasonably foreseeable abnormal operating and fault conditions.

24.23.2 The impact of transition between modes on energy flow is to be considered.

24.23.3 For **Hybrid Power (+)** notation energy flow is to be modelled by a dynamic simulation that can be exercised under normal, reasonably foreseeable abnormal operating and fault conditions and that is maintained for the life of the ship. This simulation may be deployed on board as described in *Pt 6, Ch 2, 24.16 Hybrid electrical power system components - Energy management 24.16.7* in support of off-line consequence analysis.

24.23.4 Simulation tools are to conform to appropriate National or International Standards relevant to their use and are to have been validated in an equivalent application.

24.23.5 The dynamic simulation is to be verified against the energy flows encountered during the ship’s real performance to the extent that this is reasonably practicable.

24.23.6 Proprietary simulation tools not conforming to an appropriate National or International Standard will be subject to special consideration. This consideration will include:
(a) pedigree of the underlying modelling platform on which the simulation is built;
(b) qualitative assessment of the simulation's functional capabilities and model behaviours;
(c) configuration management of the simulation model, its architecture, functional blocks and the parameters on which it is based;
(d) prior quantitative assessment of the simulation’s performance in a similar application; and
(e) an engineering justification that the validation and verification of the simulation is sufficient to enable its application in all normal and reasonably foreseeable abnormal operating and fault conditions.

24.24 Power system development and integration - Power system analysis

24.24.1 The hybrid electrical power system is to be analysed for its electrical performance under all defined operating modes and all normal and reasonably foreseeable abnormal operating and fault conditions.

24.24.2 The analysis is to include, but not be limited to:
(a) fault levels under short circuit conditions;
(b) fault flows under short circuit and overload conditions;
(c) protection device operation, discrimination and coordination;
(d) quality of power supplies;
(e) steady state performance;
(f) transient performance;
(g) earth fault currents;
(h) resonance; and
(i) common mode and circulating currents.

24.24.3 Information regarding the expected resistance, inductance and capacitance in the system and the installed components is to be provided as part of the analysis study as required by *Pt 6, Ch 2, 1.2 Documentation required for design review*. The values chosen are to be based upon the component tolerances which result in the worst case for each aspect of the analysis and are to be updated with actual values when determined from component, sub-system or system test.

24.24.4 For **Hybrid Power (+)** notation the analysis is to be by a dynamic simulation that can be exercised under all normal, abnormal and fault conditions, that is maintained for the life of the ship and that can be exercised to verify operation of the protection system including:
(a) short circuit, single or multiple phases/poles;
(b) overload;
(c) overcurrent;
(d) current imbalance;
(e) voltage imbalance;
(f) zone protection;
(g) arc fault;
(h) earth fault;
(i) under/over voltage;
(j) under/over frequency;
(k) harmonic content;
(l) quality of power supplies including degradation detection;
(m) energy flow including any regeneration by consumers;
(n) resonance and stability;
(o) transient impact of fault detection, clearance and isolation;
(p) transient impact of sources, stores and consumers being tripped or shut down;
(q) transient impact of load changes, both increase and decrease; and
(r) load sharing imbalance.

24.24.5 Simulation tools are to conform to appropriate National or International Standards relevant to their use and are to have been validated in an equivalent application.

24.24.6 The dynamic simulation is to be verified against the ship's real performance to the extent that this is reasonably practicable.

24.25 Power system development and integration - Safety functions

24.25.1 Safety functions related to the hybrid electrical power system and its constituent parts are to be clearly defined covering their purpose, their functionality and their location.

24.25.2 Safety functions are to comply with *Pt 6, Ch 1, 2 Essential features for control, alarm, monitoring and safety systems*.

24.25.3 Safety functions including ESD, emergency stop and reversionary control procedures for the hybrid electrical power system are to be defined, fully documented and made available to the Operators, maintainers and regulatory authorities.

24.26 Power system development and integration - Risk assessment

24.26.1 Where the hybrid electrical power system introduces new technologies or topologies not covered by the current Rules and Regulations then a risk assessment study is to be carried out.

24.26.2 A formal method acceptable to LR is to be used to determine if new or significantly greater hazards than those normally associated with the ship electrical power system that would be mitigated by compliance with the Rules and Regulations have been introduced (e.g. a preliminary hazard analysis or a structured checklist approach (HAZID) in accordance with ISO 31010, *Risk management – Risk assessment techniques*).

24.26.3 Where the results of this formal method establish that new hazards or exist, the risk assessment study is to be undertaken to a recognised standard that is acceptable to LR (e.g. ISO 31010, *Risk management – Risk assessment techniques*) and in accordance with *ShipRight Procedure Assessment of Risk Based Designs* and the associated annexes.

24.26.4 The objectives of the study are to:
(a) identify potential deviations from the intended operation of the hybrid electrical power system;
(b) identify the causes of each deviation, and the consequences for safety and dependability;
(c) list safeguards to minimise causes and consequences; and
(d) determine and recommend if further safeguards should be considered.

24.26.5 The scope of the study is to consider normal operation, start-up, normal shutdown, non-use and emergency shutdown of the hybrid electrical power system.

24.26.6 The risk assessment technique(s) selected are to be appropriate for their intended use and are to be accepted by LR.

24.27 Power system development and integration - System Failure Modes and Effects Analysis (FMEA)

24.27.1 An overall hybrid electrical power system FMEA is to be undertaken. The objectives of the analysis are to identify:
(a) potential failures;
(b) consequences of failure on the hybrid electrical power system and on ship operations;
(c) means to eliminate or prevent failure; and
(d) means to eliminate or minimise consequences.

24.27.2 The analysis may identify the requirement for safety measures in addition to those specifically stated in these Rules. Where additional safety measures are identified, evidence is to be provided that demonstrates how they are implemented and validated.

24.27.3 As a minimum, the scope of the analysis is to consider the 'fail safe' condition, location and arrangement of the critical system elements.

24.27.4 The analysis is to be undertaken to a recognised standard (e.g. IEC 60812, *Analysis techniques for system reliability – Procedure for failure mode and effects analysis (FMEA)*), or an equivalent and acceptable National or International Standard.

24.27.5 The FMEA is to consider but not be limited to:
(a) hidden faults that are not annunciated to or evident to the Operator where a second subsequent fault can directly result in a significant failure and hazardous condition;
(b) foreseeable inadvertent operation of the hybrid electrical power system;
(c) failure to complete transition sequences (e.g. change of operating mode or response to a fault including its detection, clearance, isolation and reconfiguration);
(d) items which can be dormantly failed and unavailable to perform their intended operation on demand (e.g. normal to backup changeover systems or standby start systems);
(e) enabling systems not part of the hybrid electrical power system (e.g. fuel supply, lubrication, cooling and ventilation systems) whose failure could affect correct functioning of the hybrid electrical power system;
(f) sensor and feedback errors in programmable electronic systems;
(g) parameter corruption in programmable electronic systems (e.g. incorrect scaling factors, control rates, alarm thresholds or trip levels);
(h) common cause effects in programmable electronic systems (e.g. network storms in networked systems, power supply faults, time dependent errors in operating systems with the potential to concurrently impact multiple redundant control or monitoring systems);

(i) common cause effects in electrical power systems (e.g. power quality outside expected range or multiple earth faults in a parallel connected system);
(j) consequential failures resulting from a single failure that are to be considered as an integral part of the single failure; and
(k) the viability of the role of the human in the detection and mitigation of faults.

24.27.6 Examples of devices in which hidden failures can occur that are detrimental to the dependability of a hybrid electrical power system include but are not limited to:
(a) protection devices – protection relays, dead-bus sensing;
(b) automatic isolation devices;
(c) circuit breaker open/close/trip functions;
(d) fault/current limitation devices;
(e) arc detection;
(f) load shedding devices;
(g) safety devices;
(h) fault detection systems;
(i) alternator current boost systems;
(j) interlocks and inter-trips;
(k) automatic change-over systems, transfer and dual-feed arrangements;
(l) stand-by start arrangements;
(m) transducers/sensors – giving an incorrect output;
(n) slow processors (e.g. watchdog functions);
(o) UPS backed-up supplies; and
(p) active failures of control systems – working but not doing what was intended,

24.27.7 Hybrid electrical power system failure modes identified through the FMEA that could impact the safe operation and performance of any component of the system (source/store/consumer/combination/distribution system/energy management) are to be notified to, and acknowledged by, the party accountable for the safety of the component through an auditable process.

24.27.8 Component failure modes that could impact the safe operation and performance of the hybrid electrical power system are to be notified to, and acknowledged by, the hybrid electrical power system integrator through an auditable process.

24.27.9 For **Hybrid Power (+)** notation FMEAs for each of the key components of the system may be requested by LR in support of the system FMEA.

24.28 Power system development and integration - Operating instructions

24.28.1 Operating Manuals are to be provided on board and submitted for information where requested by LR. The manuals are to include, but not be limited to, the following information:
(a) particulars and a description of the systems;
(b) operating instructions for the equipment and systems (including fire isolation aspects);
(c) maintenance instructions for the installed arrangements, including procedures to prevent injury from electric shock and arc flash;
(d) software configuration management procedures which are to include a list of all versions of the software installed in the system, and the settings, values of system or equipment specific configuration parameters; and
(e) output from the risk assessment processes that is necessary for the safe operation of the system under all normal and reasonably foreseeable abnormal operating conditions.

24.28.2 Overall hybrid electrical power system operating instructions are to be verified by the system designer for their completeness and correctness in all operating modes and for all foreseeable normal and abnormal operating and fault conditions. The verified instructions are to be submitted to LR.

24.28.3 Consistency between the overall system instructions and those for each component of the system is to be confirmed by the system designer.

24.28.4 All mitigating actions arising from the FMEA that require manual intervention are to be confirmed as included in the operating instructions.

24.28.5 Procedures for reversionary (e.g. manual) control of the hybrid electrical power system are to be included and are to be verified during practical operation.

24.29 Power system development and integration - Operator training

24.29.1 Training needs specific to the ship and necessary for its safe operation are to be identified and documented in the ship's operating manual.

24.29.2 For **Hybrid Power (+)** notation any ship-specific Operator training is to be verified by the system designer for its completeness and correctness in all operating modes and for all foreseeable normal and abnormal operating and fault conditions with evidence of verification submitted to LR.

24.30 Power system development and integration - Through-life accountability

24.30.1 The activities detailed in *Pt 6, Ch 2, 24.18 Power system development and integration - General* to *Pt 6, Ch 2, 24.29 Power system development and integration - Operator training* are to be maintained throughout the whole lifecycle of a ship and are to be verified at Periodic Survey.

24.30.2 Proposed changes to the hybrid electrical power system including its components that may impact on system safety or dependability are to be formally reviewed and accepted by the system integrator before their incorporation with details submitted to LR.

24.30.3 For **Hybrid Power (+)** notation details of incidents arising during any and all operations of the hybrid electrical power system that has, or could have, resulted in a hazardous consequence for people, platform or the environment are to be monitored.

24.31 Verification requirements

24.31.1 Compliance with the requirements in *Pt 6, Ch 2, 1.2 Documentation required for design review 1.2.17* is deemed to satisfy the functional requirements and performance requirements above.

24.32 Testing and trials

24.32.1 Testing and trials in accordance with *Pt 6, Ch 2, 21 Testing and trials* are to be carried out as applicable.

24.32.2 Where required by the *Rules and Regulations for the Classification of Ships, July 2019*, items are to be constructed under survey.

24.32.3 Materials are to be approved, manufactured and tested in accordance with a standard acceptable to LR.

24.32.4 The fault ride-through capability of the system is to be demonstrated during practical tests on the system.

24.32.5 Quality of power supply testing of the system and the components is to be carried out to prove the equipment is capable of operating under the variations specified by the hybrid electrical power system integrator and accepted by LR for all normal and reasonably foreseeable abnormal operating conditions.

24.32.6 Where considered necessary by LR, additional testing may be required.

24.32.7 Satisfactory operation and load testing of the hybrid electrical power system in harbour and during sea trials are to be witnessed by LR.

24.32.8 Measurements are to be taken as part of the trials to verify that the installation will provide a quality of power supply in accordance with the values declared by the hybrid electrical power system integrator as described in *Pt 6, Ch 2, 24.17 Transversal requirements*.

24.32.9 For **Hybrid Power (+)** notation additional trials are to be carried out to:
(a) verify that the system delivers the determined levels of performance as described in *Pt 6, Ch 2, 24.5 Hybrid electrical power system performance - System performance targets*;
(b) verify that the system fulfils the redundancy principles defined by the hybrid electrical power system integrator as described in *Pt 6, Ch 2, 24.6 Hybrid electrical power system performance - Dependability principles*;
(c) verify the correct operation of the additional energy management functionality described in *Pt 6, Ch 2, 24.16 Hybrid electrical power system components - Energy management*;
(d) verify that the system performs in accordance with its simulation(s) as described in *Pt 6, Ch 2, 24.23 Power system development and integration - Energy flows* and *Pt 6, Ch 2, 24.24 Power system development and integration - System analysis*; and
(e) verify the findings of the FMEA analysis detailed in *Pt 6, Ch 2, 24.27 Power system development and integration - System Failure Modes and Effects Analysis (FMEA)* and the response of the system to simulated failures.

Part 7, Chapter 11
Arrangements and Equipment for Environmental Protection (ECO Class Notation)

■ *Scope*

The goal of this chapter is to provide for the design and construction of ships having a reduced environmental impact during operation compared to ships designed and constructed solely in accordance with the relevant minimum statutory requirements of the MARPOL convention and as such the requirements in this chapter necessarily exceed the relevant minimum statutory requirements of the MAROL convention.

■ *Section 1*
General Requirements

1.2 ECO class notation: minimum requirements and additional characters

1.2.2 *Pt 7, Ch 11, 3 Supplementary characters* contains additional requirements. Ships complying with these requirements will be eligible for one or more of the following associated supplementary characters, as applicable:

A Anti-fouling coatings.
BIO Bio-fouling.
~~**BWT** Ballast water treatment.~~
CRM Cargo residue minimisation.
EAL Environmentally Acceptable Lubricants
~~**EEDI-1, EEDI-2,**~~ **EEDI-3** Energy efficiency design index.
~~**SEEMP**~~**, EnMS** Ship energy efficiency management.
GW Grey water.
IBTS Integrated Bilge Water Treatment System.
~~**NO$_{x2}$,**~~ **NO$_{x3}$ Nitrogen Oxides (NO$_x$) exhaust emissions.**
OW Oily bilge water.
P Protected oil tanks.
R Refrigeration systems.
~~**SOx, DIST Sulphur Oxides (SO$_x$) exhaust emissions.**~~
SOx-EGCS Exhaust Gas Cleaning System
TC Enhanced tank cleaning.
VECS-L, VOC-R Vapour emission control systems (tankers only).

1.5 Information to be submitted

(Part only shown)
1.5.3 Certificates
(a) MARPOL certificates or statements on behalf of the ship’s Flag State, including:
- Engine International Air Pollution Prevention (EIAPP) Certificate or Statement of Compliance with the NO$_x$ emission requirements of MARPOL ~~*Annex IV of MARPOL 73/78 Regulations for the Prevention of Pollution by Sewage from Ships*~~ *Annex VI Regulations for the Prevention of Air pollution from Ships*, for each engine to which *Regulation 13 – Nitrogen Oxides (NOx)* applies;

(c) Incinerator Type Approval Certificate ~~or equivalent, as required by *Pt 7, Ch 11, 2.9 Garbage handling and disposal 2.9.2*.~~

(Part only shown)
1.5.5 Information and plans:
(c) Description of the method(s) by which the ~~NO^x~~ NOx certified value has been achieved~~. The supplementary characters (**NOx-1** and **NOx-2**)~~ and the ~~NO^x~~ NOx Technical File for the engine plus the ~~NO^x~~ NOx reducing device (**NOx-3** supplementary character).
(e) Details of the Exhaust Gas Cleaning System demonstrating compliance with MARPOL *Annex VI Regulations 14.1* and *14.4* are to be provided, including the approved SO$_X$ Emissions Compliance Plan (SECP) and the certified value of SO$_2$/CO$_2$ emission ratio, where applicable.

Existing list items (e) to (r) have been renumbered (f) to (s).

~~(s)~~ (t) Ballast water treatment arrangements~~, as applicable (for supplementary **BWT** character only)~~.

Existing list item (t) have been renumbered (u).
~~(u)~~ (v) Energy Efficiency Design Index Statement of Compliance or certificate ~~(supplementary characters **EEDI-1**, **EEDI-2** and **EEDI-3** only)~~.

Existing line items (v) to (y) have been renumbered (w) to (z).
~~(z)~~ (aa) LR Statement of SEEMP conformance and associated documentation ~~(supplementary character **SEEMP** only)~~.

Existing line item (aa) has been renumbered (ab).

■ *Section 2*
Minimum Requirements

2.1 General

(Part only shown)

2.1.1 It is a prerequisite for assignment of the **ECO** notation that the ship:

(a) complies with the Anti-fouling Convention, the Ballast Water Convention~~, except as modified by *Pt 7, Ch 11, 2.11 Ballast water 2.11.4*,~~ and all Annexes to *MARPOL - International Convention for the Prevention of Pollution from Ships* 73/78, as amended, applicable to the ship;

2.3 Sulphur Oxides (SO_x)

2.3.2 The maximum sulphur content of fuel oil to be used on board is not to exceed ~~3,00~~0,1 per cent m/m.

2.3.6 ~~Alternative arrangements providing an equivalent level of environmental protection will be considered. If an exhaust gas cleaning system is fitted, it is to be certified to *Resolution MEPC.259(68) - 2015 Guidelines for Exhaust Gas Cleaning Systems - (Adopted on 15 May 2015)*.~~ If an Exhaust Gas Cleaning System is fitted, it is to be certified to *Resolution MEPC.259(68) - 2015 Guidelines for Exhaust Gas Cleaning Systems - (Adopted on 15 May 2015)*. The system is to operate at all times regardless of the area in which the vessel operates.

2.3.7 Where petroleum-based distillate or residual fuels, with a sulphur content exceeding 0,1 per cent m/m, are used with an approved Exhaust Gas Cleaning System, the SO_2(ppm)/CO_2(%v/v) emission ratio method is to be used for determination of the corresponding emission ratio value, as specified in the *Table 11.2.1 Fuel oil sulphur limit and corresponding emission ratio value*.

Table 11.2.1 Fuel oil sulphur limit and corresponding emission ratio value

Fuel oil Sulphur Content (% m/m)	Emission ratio SO_2 (ppm)/CO_2 (%v/v)
0,10	4,3

Existing sub-Section 2.4 has been deleted.

~~2.5~~ 2.4 Refrigeration systems

Existing paragraph 2.5.1 has been renumbered 2.4.1.

~~2.5.2~~ 2.4.2 The use of chlorofluorocarbons (CFC) ~~in existing,~~ and hydrochlorofluorocarbons (HCFCs) in existing and new refrigeration or air conditioning installations is prohibited.

~~2.5.3~~ 2.4.3 Where possible, natural refrigerants, such as ammonia, carbon dioxide and hydrofluoroolefins (HFOs), should be used.~~ If halocarbon~~ Where hydrofluorocarbon (HFC) refrigerants are used, they are to have an Ozone Depleting Potential (ODP) rating of zero and a Global Warming Potential (GWP) of less than 1950, based on a 100- year time horizon.

Existing paragraphs 2.5.4 to 2.5.15 have been renumbered 2.4.4 to 2.4.15.

2.4.16 **Flammability of Refrigerants** - The Refrigerant Classification Scheme, ISO 817:2014+A1:2017, is to be considered regarding the flammability class of the refrigerant. Where A2L and higher refrigerants are to be used in systems they are to be designed specifically to take into account their flammability and toxicity characteristics. These refrigerants may not replace non-flammable refrigerants when retrofitting a system.

(a) Where refrigerants are classed as A2L and higher, Sections *Pt 7, Ch 11, 2.4 VOC Refrigeration systems 2.4.4 to Pt 7, Ch 11, 2.4 VOC Refrigeration systems 2.4.15* are applicable with the following additional requirements:
  - Spaces are to be fitted with a non sparking mechanical ventilation system, with a capacity of at least 30 air changes per hour, which is arranged to avoid areas where gas may accumulate, taking into account the density of the vapour and potential ignition sources. The ventilation system shall be separated from those serving other spaces.
  - All leak detection equipment shall be suitable to use in a hazardous areas and means are to be provided to measure oxygen levels prior to personnel entering the space.
  - The leak detection is to be set to alarm at gas concentrations above 30 per cent lower flammable limit (LFL),
  - A risk assessment reviewing the application, location of components and the installed refrigerant charge.
  - All personnel carrying out maintenance, inspections, servicing and installation must hold an appropriate certificate for handling such refrigerants
  - All spaces containing these refrigerants are to be indicated on a hazardous area plan.

Existing sub-Section 2.9 has been deleted.

Existing sub-Section 2.10 has been renumbered 2.8.

Existing sub-Section 2.11 has been deleted.

Existing sub-Section 2.12 has been renumbered 2.9

■ *Section 3*
Supplementary characters

Existing sub-Section 3.3 has been deleted.

Existing sub-Sections 3.4 to 3.5 have been renumbered 3.3 to 3.4.

~~3.6~~ 3.5 Energy Efficiency Design Index – ~~EEDI-1, EEDI-2,~~ EEDI-3 character~~s~~

Existing paragraph 3.6.1 has been renumbered 3.5.1.

Existing paragraphs 3.6.2 and 3.6.3 have been deleted.

Existing paragraph 3.6.4 has been renumbered 3.5.2.

~~3.7~~ 3.6 Energy management – ~~SEEMP and~~ EnMS character~~s~~

Existing paragraphs 3.7.1 and 3.7.2 have been deleted.

Existing paragraph 3.7.3 has been renumbered 3.6.1.

Existing sub-Section 3.8 has been renumbered 3.7.

~~3.9~~ 3.8 Grey water – GW character

Existing paragraph 3.9.1 has been renumbered 3.8.1.

(Part only shown)
~~3.9.2~~ 3.8.2 Where it is not intended that the effluent is recycled or re-used for any purpose, the effluent of the grey water treatment plant is to meet the following standards:

(b) Total Suspended solids:

- The method of testing is to be as given in *Resolution MEPC.~~159(55)~~227(64) - Revised Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants - (Adopted on 5 October 2012)*.

Existing paragraphs 3.9.3 to 3.9.9 have been renumbered 3.8.3 to 3.8.9.

3.9 Nitrogen oxides ~~NO_{x2}~~, NO_{x3} character

Existing paragraphs 3.10.1 to 3.10.3 have been deleted.

Existing paragraphs 3.10.4 to 3.10.9 have been renumbered 3.9.1 to 3.9.6.

Existing sub-Section 3.14 has been deleted and replaced with below.

3.13 Sulphur oxides – Exhaust Gas Cleaning System SOx-EGCS character

3.13.1 Where Exhaust Gas Cleaning Systems (EGCS) discharge liquid effluents overboard, the Guidelines on EGCS in section *10 Washwater* of *Resolution MEPC.259(68) - 2015 Guidelines for Exhaust Gas Cleaning Systems - (Adopted on 15 May 2015)* are to be followed.

Existing sub-Sections 3.15 and 3.16 has been renumbered 3.14 and 3.15.

Part 7, Chapter 16
Towing Winch Emergency Release Systems

■ *Section 1*
Towing winch emergency release systems - goal-based framework

1.1 Goal-based framework

1.1.1 The purpose of this Section is to present a goal-based approach to the requirements for towing winch emergency release systems provided on towing winches that are used for towing ships within close quarters, ports or terminals.

1.1.2 The goals, functional requirements and performance requirements listed herein relate to design, construction and testing of the emergency release system.

1.1.3 The list of goals is as follows:
(a) The towing winch emergency release system is designed, constructed and tested through life to release loads safely, if necessary, in the event of an incident.
(b) The towing winch emergency release system is designed, constructed and tested in accordance with appropriate documented requirements.

1.1.4 The list of functional requirements is as follows:
(a) The emergency release is to operate under all normal and reasonably foreseeable abnormal conditions.
(b) The towline load is to be released in a controlled manner.
(c) Control systems are to function in a safe manner in all foreseen operational conditions.
(d) Activation of the emergency release shall not expose the crew to any additional hazard.
(e) Towline load is to be released quickly enough to prevent capsize of the tug.
(f) The release system is to operate across the full range of possible towline loads, fleet angles and ship heel angles.
(g) The emergency release control system is to be designed to ‘fail-safe’, *see Pt 6, Ch 1, 2.5 Control systems, general requirements 2.5.3*.
(h) Necessary information and instructions to maintain and test the emergency release system are to be available.
(i) Emergency winch release is to be tested to demonstrate functionality and correct operation at appropriate intervals.

1.1.5 The list of performance requirements is as follows:
(a) The emergency release is to operate at 100 per cent of the maximum design load.
(b) An alternative source of energy is to be provided and is to be available in dead ship condition, sufficient to allow for three attempts to release the towline and/or hold the brake open for sufficient time to release the full length of the towline or five minutes, whichever is lesser.
(c) Towline load required to rotate the winch drum once emergency release has been activated is to be no greater than:
  - the lesser of five tonnes or five per cent of the maximum design load when two layers of towline are on the drum; or
  - 15 per cent of the maximum design load where it is demonstrated that this resistance to rotation does not exceed 25 per cent of the force that will result in listing sufficient for the immersion of the lowest unprotected opening.
(d) The towline release is to be controlled to prevent the towline from becoming jammed.
(e) Control systems are to provide all necessary alarms to alert the crew in the event of failure affecting capability of the emergency release system.
(f) Arrangements of emergency release system controls are to prevent accidental or non-deliberate activation of the release system.
(g) Operation of the emergency release is to be possible from the bridge and from safe locations on the deck.
(h) The load is to be released within a maximum of three seconds.
(i) A weak link or similar arrangement is to be provided connecting the towline to the winch drum.
(j) All locations from where the emergency release can be operated are to have a full view of the towing winch and surrounding area.

1.2 LR accepted solution for towing winch emergency release systems in satisfying the goal-based framework

1.2.1 For LR accepted solutions to satisfactorily meet the goal-based framework *see Pt 7, Ch 16, 2 Towing winch emergency release systems – scope and definitions* to *Pt 7, Ch 16, 4 Validation of requirements for emergency release systems*.

1.2.2 The application of the prescriptive content in this Chapter in its entirety is considered to satisfy the functional and performance requirements of this chapter as applied to towing winch emergency release systems.

1.2.3 Alternative proposals for meeting the goal-based framework of this Section will be specially considered.

■ *Section 2*
Towing winch emergency release systems - scope and definitions

2.1 Scope

2.1.1 The requirements of this Chapter apply to winch emergency release systems provided on towing winches that are used for towing ships within close quarters, ports or terminals.

2.1.2 The requirements of this Chapter are not applicable to towing winches on board ships used solely for long distance ocean towage, anchor handling or similar offshore activities.

2.1.3 *See Pt 4, Ch 3, 7 Towing equipment* for requirements for towing winches and associated equipment.

2.2 Definitions

2.2.1 **Emergency release system** refers to the mechanism and associated control arrangements that are used to release the load on the towline in a controlled manner under both normal and dead ship conditions.

2.2.2 **Maximum design load** is the maximum load that can be held by the winch as defined by the manufacturer (the manufacturer’s rating).

2.2.3 **Fleet angle** is the angle between the applied load (towline force) and the towline as it is wound onto the winch drum, *see Figure 16.2.1 Towline ‘fleet angle’*.

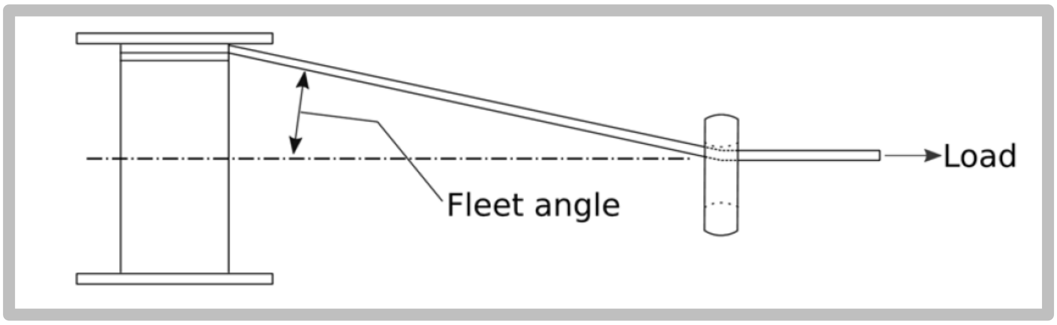


Figure 16.2.1 Towline ‘fleet angle’

■ *Section 3*
Emergency release system requirements

3.1 General requirements

3.1.1 The in-board end of the towline is to be attached to the winch drum with a weak link or similar arrangement that is designed to release the towline at low load.

3.1.2 All towing winches are to be fitted with an emergency release system.

3.1.3 Where required for testing the winch, adequately sized strong points are to be provided on deck.

3.2 Emergency release system operation

3.2.1 The emergency release system is to operate across the full range of towline loads, fleet angles and ship heel angles under all normal and reasonably foreseeable abnormal conditions (including, but not limited to vessel electrical failure, variable towline load (e.g. due to high strain rate loadings, i.e. ‘snap loads’), etc.).

3.2.2 The emergency release system shall be capable of operating with towline loads up to at least 100 per cent of the maximum design load.

3.2.3 The emergency release system is to function as quickly as is reasonably practicable and within a maximum of three seconds after activation.

3.2.4 The emergency release system is to allow the winch drum to rotate and the towline to pay out in a controlled manner such that, when the emergency release system is activated, there is sufficient resistance to rotation to avoid uncontrolled unwinding of the towline from the drum. Spinning (free, uncontrolled rotation) of the winch drum is to be avoided, as this could cause the towline to get jammed and disable the release function of the winch.

3.2.5 Once the emergency release is activated, the towline load required to rotate the winch drum is to be no greater than:
(a) the lesser of 5 tonnes or 5 per cent of the maximum design load when two layers of towline are on the drum; or
(b) 15 per cent of the maximum design load where it is demonstrated that this resistance to rotation does not exceed 25 per cent of the force that will result in listing sufficient for the immersion of the lowest unprotected opening. Unprotected openings include openings fitted with closing appliances that must remain open for operational reasons.

3.2.6 An alternative source of energy is to be provided such that normal operation of the emergency release system can be sustained under dead ship conditions.

3.2.7 The alternative source of energy required by *Pt 7, Ch 16, 3.2 Emergency release system operation 3.2.6* is to be sufficient to achieve the most onerous of the following conditions (as applicable):
(a) Sufficient for at least three attempts to release the towline (i.e. three activations of the emergency release system). Where the system provides energy for more than one winch, it is to be sufficient for three activations of the most demanding winch connected to it.
(b) Where the winch design is such that the drum release mechanism requires continuous application of power (e.g. where the brake is applied by spring tension and released using hydraulic or pneumatic power), sufficient power is to be provided to operate the emergency release system (e.g. hold the brake open and allow release of the towline) in a dead ship situation for a minimum of five minutes. This may be reduced to the time required for the full length of the towline to feed off the winch drum at the load specified in *Pt 7, Ch 16, 3.2 Emergency release system operation 3.2.5* if this is less than five minutes.

3.3 Emergency release control system

3.3.1 Emergency release operation must be possible from the bridge and from the winch control station on deck. The winch control station on deck is to be in a safe location.

3.3.2 The emergency release control is to be located in close proximity to the emergency stop button for winch operation and both should be clearly identifiable, clearly visible, easily accessible and positioned to allow safe operability.

3.3.3 The emergency release function is to take priority over any emergency stop function. Activation of the winch emergency stop from any location is not to inhibit operation of the emergency release system from any location.

3.3.4 Emergency release system control buttons are to require positive action to cancel. The positive action may be made at a different control position from the one where the emergency release was activated. It must always be possible to cancel the emergency release from the bridge regardless of the activation location and without manual intervention on the working deck.

3.3.5 Controls for emergency use are to be protected against accidental activation.

3.3.6 Indications are to be provided on the bridge for all power supply busbar voltage and frequency and/or hydraulic/pneumatic pressure levels related to the normal operation of the emergency release system. Alarms are to activate automatically if any level falls outside of the limits within which the emergency release system is fully operational.

3.3.7 Wherever practicable, control of the emergency release system is to be provided by a hard-wired system, fully independent of programmable electronic systems.

3.3.8 Computer-based systems that operate or may affect the control of emergency release systems are to meet the requirements of *Pt 6, Ch 1, 2.13 Programmable electronic systems – Additional requirements for essential services and safety critical systems.*

■ *Section 4*

Validation of requirements for emergency release systems

4.1 Documentation

4.1.1 Operation and maintenance procedures for the emergency release system are to be incorporated in the vessel's operations manual.

4.1.2 Components critical for the safe operation of the emergency release system are to be identified by the manufacturer and included in the operations manual on board the vessel.

4.1.3 The method for periodic testing in accordance with manufacturer's recommendations of the winch is to be documented, a copy of which is to be kept on board and made available to the Surveyor on request.

4.2 Testing and trials

4.2.1 All testing and trials defined within this Section are to be carried out under survey to the satisfaction of the attending Surveyor.

4.2.2 For each emergency release system, the requirements of *Pt 7, Ch 16, 3.2 Emergency release system operation* are to be verified either at the manufacturer's works or as part of the commissioning of the towing winch when it is installed on board. Where verification solely through testing may present a safety hazard, testing may be combined with inspection, analysis or demonstration in agreement with LR.

4.2.3 The performance capabilities and operating instructions of the emergency release system are to be included in the operating manual which is to be made available on board the ship on which the winch has been installed.

4.2.4 The full functionality of each emergency release system fitted is to be tested as part of the shipboard commissioning trials to the satisfaction of the attending Surveyor. Testing may be conducted either during a bollard pull test or by applying the towline load against a strong point on the deck of the tug that is certified to the appropriate load.

4.2.5 Where the performance of the winch in accordance with *Pt 7, Ch 16, 3.2 Emergency release system operation* has previously been verified, the load applied for the installation trials is to be at least the lesser of 30 per cent of the maximum design load or 80 per cent of vessel bollard pull.

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